



naya shikshak

NAYA SHIKSHAK

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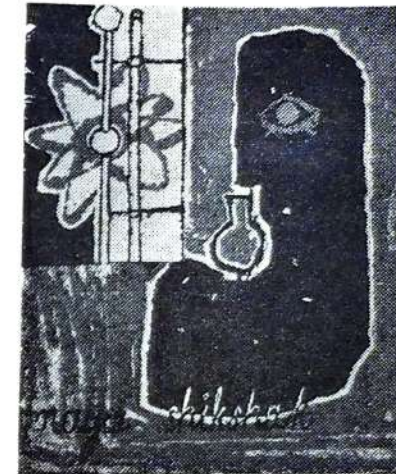
परिनिष्पन्ने च वस्तुनि प्रमाणान्तराणामस्त्यवकाशो
यथा पृथिव्यादिषु । यथा च श्रुतीनां परस्परविरोधे
सत्येकवशेनेतरा नीयन्ते, एवं प्रमाणान्तरविरोधेऽपि
तद्वशेनैव श्रुतिनीयत । दृष्टसाम्येन चादृष्टमर्थं समर्थ-
यन्ती युक्तिरनुभवस्य संनिवृष्यते ।

When an objective reality such as the earth
is concerned it is possible to gain knowledge
by means other than revelation. When there
is a conflict between different scriptural texts
we are led by the strongest; similarly when
there is a conflict (in such matters) between
the scriptures and other (rational) means of
knowledge we might be led by the latter.
Reason is nearer to experience since it
proceeds from the known to the unknown.

—शंकर on Brahmsutras 2.1.4.

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EDUCATION SCIENCE and the COMMUNITY

A distinguished scientist and educational thinker calls for hard and sustained work, serious thinking and research lest the potentialities remain entombed in the pyramids of frills and ostentation.

By D. S. KOTHARI

THE VITAL role of science, in fact of all education, in India should be to fight ignorance, poverty and disease, and function as a powerful instrument to bring about a social transformation, so that millions could live longer and happier lives. The expectation of life at birth in India is only about half of that in the advanced countries. In India the bottom-tenth of the population, which in numbers equals the population of U. K., had as its total yearly income no more than what the people of U. K. spend on cigarettes and tobacco. In the modern world rich countries are those which are rich in science and poor are those which are poor in science.

Science must think in terms of the millions in the country

In stirring words Jawaharlalji declared at the 1947 Science Congress : "For a hungry man or a hungry woman, Truth has little meaning. He wants food. And India is a hungry starving country, and to talk of Truth and God, and even of

many of the fine things of life, to the millions who are starving, is a mockery. We have to find food for them, clothing, housing, education, health and so on, all the absolute necessities of life that every man should possess. When we have done that we can philosophise and think of God. So, science must think in terms of the few hundred million persons in India. Obviously, you can only think in those terms and work along those lines on the wider scale of co-ordinated planning”.

In the past there have been great and flourishing civilisations, but the lot of the common man was almost invariably one of miserable existence. For instance, at the height of the Athenian civilisation, it was said that to abolish slavery would be to abolish Athens itself; and Aristotle asserted that slave labour would remain the foundation of culture so long as human ingenuity could not devise machines for doing manual work. It has taken more than two thousand years to achieve this end; and now man has the means to build a civilisation where all can live in peace, plenty and happiness.

The key to an improvement of the standard of living in a country is, no doubt, science and technology and industrialisation. However, it is important to recognise that in this matter there can be no half-way house. Once we start moving along the road of science and industrialization, we disturb the old equilibrium reached and maintained over many centuries. Disturbance of the old equilibrium brings about a host of new problems, of which the most important is a rapid rise in population as a consequence largely of improved sanitation and control of epidemics. We must move towards a new equilibrium, based on a full utilisation of science and technology; and it should be achieved as quickly as possible. But if we march with faltering steps and if our commitment and convictions are half-hearted and lack faith, then, the new situation may turn out to be worse than the earlier one. Tinkering with science and technology can often make things worse than what they were before.

Science and Technology, and Labour Force

IN THIS CONTEXT it is important to recognise the distinction between science and technology. In earlier times science and technology were separate activities. Technology was based largely on empirical experience, on trial and error, rather than on science. The electrical industry was probably the first to be science-based, next came the chemical industry, and now agriculture is also becoming a branch of applied science. This close interlocking and inter-dependence between science and technology is a characteristic feature of the contemporary world and it is this which largely has led to their explosive growth. It is again largely because of this that

growth rates in GNP of five per cent and higher have been realised by industrialised countries in recent years.

A science-based technology needs an educated working population (labour force). The terrific expansion in education which has taken place in industrialised countries during the last fifty years or so is a direct consequence of the permeation of science into industry and agriculture. This is well brought out if we compare, say, the educational structure of the labour force of the U.S.A. with that in our country. The table below gives a broad, and to some extent an idealised, picture of the present situation in the two countries :

	<i>Proportion of the total working population</i>	
	U.S.A.	India
Completed secondary school	1/2	1/30
Completed college education	1/10	1/300
First degree in science and engineering	1/100	1/2,000
Doctorate degree in science and engineering	1/1,000	1/50,000

It would need a deliberate policy, terrific effort and massive resources to transform within a few decades the educational structure of our labour force to make it comparable to that in industrialised countries; but above all it would need an unflinching determination, sense of social responsibility and spirit of dedication on the part of the educated elite to give the highest consideration and priority to the interests and well-being of the rural population and the under-privileged sections of society.

Knowledge, a sealed book to millions

THE FIRST THING that strikes us is the dismal fact that more than 350 million of our people are illiterate. This number is more than what was at the time of Independence (1947). It has been said that the percentage of literacy under Asoka was higher than in India today. Knowledge, especially scientific and technical knowledge, using the term in its broadest sense, can provide a most potent instrument for economic and social transformation. And yet today it has hardly any meaning for the major part of our vast population. Illiteracy has always been an unfortunate, dangerous and derogatory thing, but never more so than in the present ‘age of science and the atom’. It is hardly possible to achieve and sustain industrialisation unless the bulk of the population (say, at least 60 per cent) is literate and has some acquaintance with rudiments of science and modernisation. As things are

today, the great treasure-house of knowledge, rapidly growing every day, is a sealed book to hundreds of millions in our country—it is to them alien and inaccessible. The highest priority therefore should go to the eradication of illiteracy and to primary education. But what about the resources required for this colossal task ? Gandhiji's history-making answer was : "But, as a nation we are so backward in education that we cannot hope to fulfil our obligations to the nation in this respect in a given time during this generation, if the programme is to depend on money. I have therefore made bold, even at the risk of losing all reputation for constructive ability, to suggest that education should be self-supporting. By education I mean an all-round drawing out of the best in child and man—body, mind and spirit.....I would therefore begin the child's education by teaching it a useful handicraft and enabling it to produce from the moment it begins its training. Thus every school can be made self-supporting, the condition being that the state takes over the manufactures of these schools". The essential point is that effective education on a massive scale, and of adequate quality, can hardly be organised and sustained unless the system itself makes a direct and significant contribution to national productivity and thus partly meets its own cost.

Synoptic Picture of Higher Education

WE HAVE at present sixty-three Universities in the country. The number at the time of Independence in 1947 was 20. The first three Universities at Calcutta, Bombay and Madras were established in 1857, and the fourth University was started at Allahabad in 1887. There was then a long gap, and it was only in 1916 that the Universities of Banaras and Mysore were set up.

The present picture in broad terms of Indian education is that the effort in technology and specially in agriculture is far less than it should be in relation to our pressing and basic needs. If we take a group of ten students in higher education in India, selected at random, six out of them would be in arts, commerce and law, three in science and only one accounts for engineering, medicine and agriculture. In the U.K., on the other hand, out of every ten students, four are in arts and commerce, three in science and three in engineering, medicine and agriculture. Another interesting fact which may be noted is about the size of colleges. A fairly large proportion of our colleges is below what could be regarded as *optimum strength*. The distribution is given in the following table (statistics refer to the year 1964-65) :

Enrolment	Number of colleges within the range of enrolment shown in column (1)	Percentage of the total	Number of arts, science, commerce colleges	Percentage.	Number of professional colleges.	Percentage
Less than 100	328	15.9	175	11.3	153	29.2
Between 100-499	896	43.4	640	41.5	256	48.9
Between 500-999	459	22.2	377	24.5	82	15.6
Between 1000-1999	329	15.9	299	19.4	30	5.7
2000 and above	54	2.6	51	3.3	3	0.6
Total	2066	100.0	1542	100.0	524	100.0

Without going into details it is worth stressing that in the near future we should think more of strengthening & improving existing colleges, rather than setting up new ones. The same, of course, applies with even greater force to universities. Perhaps, the most basic reform needed in our educational system is to increase the number of working days in a year and also the number of working hours in a week. At college level in "advanced countries" students on an average, work for about 40 to 50 hours per week : this includes class attendance. In our country, compared to this, the work put in by students is relatively small; but here the main difficulty is that students do not have even the barest facilities for quiet study and contemplation neither do they have the books nor the physical facilities required for the purpose. It is proposed that during the next five years or so provision of what may be called *reading homes* may be made for at least 20% of the total enrolment in the universities. The reading homes will provide adequate number of multiple copies of books for the use of students. We should also put in special effort to produce first-rate books, and at cheap prices to make them within easy reach of students.

Education and Research in Agriculture

LET ME TURN TO what perhaps is our most pressing need—to industrialize agriculture, to make it science and technology based. This means that agricultural education, both its expansion and improvement in quality, should receive

much greater and more vigorous attention than has been the case. In countries where agriculture has been modernised the output has increased rapidly and where agriculture has not been linked to science the crop yields have remained almost stationary. Agricultural yields in India are nearly the lowest in the world today. Take the production of rice; the yield per acre in Italy is 3,240 lbs., in Japan 2,800 lbs., in China 1,600 lbs., but in India it is 900 lbs. In the case of wheat, the yield per acre in Japan is 2,740 lbs., in the U.S.A. 1,610 lbs., in Denmark it is as high as 4,130 lbs., whereas in India it is about 850 lbs. It is generally recognised that through improvement and modernisation of agriculture, it should be possible to double or even triple agricultural production in many parts of Asia, Africa and South America where the yields at present are below about 1,000 lbs. per acre.

In this context I may mention of a report of unusual interest and value for the Indian subcontinent which has recently appeared. The report is by a multi-disciplinary panel of experts appointed by the U.S. President at the request of the Pakistan Government, to study the waterlogging and salinity problem in west Pakistan. Dr Roger Revelle (till recently Dean of Research at California University) was Chairman of the panel. It is estimated that due to waterlogging and accumulation of salt in the soil, about 0.2 to 0.4 per cent of the irrigated area is being rendered waste every year in West Pakistan. Says the Report – “We have the wasteful paradox of a great and modern irrigation system pouring its water into lands cultivated as they were in the Middle Ages. Ploughing is done by a wooden plough of ancient design, pulled by a pair of bullocks enfeebled by undernourishment. Unselected seeds are sown broadcast. Chemical fertilizers and pesticides are comparatively little known. Egypt uses 100 times more fertilizers per acre than does Pakistan; Japan more than 200 times as much and yields per acre in both countries average about three times those of Pakistan”. The most encouraging aspect of the Report is the conviction of the Panel that within a generation agriculture can undergo a revolution of the kind which has occurred in countries such as United States and Japan; and a rate growth of agricultural yields can be achieved and maintained which will not only meet adequately the food requirements of the rising population but also provide a firm base for industrial development. The capital cost of the scheme is estimated to be of the order of \$ 100 per acre. The recommendations of the Report, as also the entire study, are of considerable importance in relation to the problems of Indian agriculture. The Report has also stressed the importance of research and development and education as an essential foundation to ensure continuing improvement in agricultural production.

Research and Development

RESEARCH AND DEVELOPMENT has now become a major national activity in advanced countries, and is gaining rapid momentum in developed countries. In the U. S. A. the total national expenditure on research and development has been doubling every 4 to 5 years in recent years and now totals more than 20 billion a year (about Rs. 10,000 crores). This represents 3 per cent of the GNP – it was 1.4 per cent twenty years ago. It is important to observe that increasing R & D effort is closely linked to an increase in the scientific and technical manpower. The manpower in science and technology in the U.S.A. has increased from 1.5 per cent of the labour force in 1940 to 3.2 per cent in 1960, and is expected to rise to 4.7 per cent in 1970. The R & D expenditure in India is about 0.3 per cent of the GNP and scientists and engineers constitute about 0.05 per cent of the population.

Education and Economic Growth : Work Experience

EDUCATION in the widest meaning of the word is vital to economic growth, security and welfare. It provides a most powerful element in creating a social and psychological ethos necessary for economic progress and adjustment to the new rapidly changing world of today. *The next decade (1965-75) in our country may well be the decade of activating and modernising education and, what is most important, linking it to productivity, national goals and aspirations.*

The most important thing basic to the whole process is to generate in the educational institutions at all levels a climate of *hard and sustained work, zest and dedication*, concentration on the essential tasks and elimination of all frills and ostentation. The broad objectives of the educational plan (for the next decade) may be stated as :-

(a) To impart *effective* elementary education up to at least 5 years to all children.

It is equally important to achieve *about 60 per cent literacy in the total population by 1975.*

It is not possible to realise and sustain industrialisation without a major proportion of the working population being literate and aware, to some extent, of the spirit of modernisation and innovation.

(b) Improvement in the quality of education at all levels and to lay *stress on science and technology with special emphasis (at least during the early phase of the programme) on agriculture and allied subjects.*

(c) *To organise 'work experience' as an essential element of education :* The "work experience" could take a variety of forms of which the most important would be participation in productive work on farms, in factories, workshops and so on. Work experience will soften the distinction between manual work and mental work; make entry into employment easier; contribute to national productivity; will help national integration; and will help to develop in the youth a sense of social responsibility.

For students in rural areas *work experience* with advantage could be largely agriculture-based. It should, of course, have a thoroughly practical bias. The instructional and supervisory staff could include a combination of trained experts and skilled farmers. In this context one is reminded of Defence scientific work which, for its effective organisation, requires a combination of scientists and soldiers – the first bringing scientific knowledge and the latter providing 'combat experience'. Similarly, on the agricultural front we need combined teams of scientists and expert farmers.

To attract a reasonable proportion of the best young men into professions most important in relation to national development, it is necessary that the relevant subjects of study enjoy adequate status in the national economy and set up. If, say, the prestige of space research becomes unduly high in relation to agricultural research one cannot normally expect the most gifted of the youth to go in for agricultural research. If building of pyramids is considered more important than improvement of agriculture, then the best men become pyramid designers rather than agricultural scientists. This happened on the banks of the Nile thousands of years ago and one of the great civilisations of antiquity got entombed in the pyramids at almost the height of its glory.

When there is a deficiency of competent men, it is wiser to invest them generally in the universities, thus combining teaching and research. If the investment and effort exceed a certain critical size (and with proper feed-back), it would generate a sort of chain process providing many more and more able men. In the age of science it is most important that education generates and promotes in the youth a spirit of free enquiry, tolerance, open-mindedness and ability to adjust to change and innovation. Survival depends no longer on conformity and tradition : it depends and demands a continuing self-renewal of the individual and of the society. To quote from J. N. Gardner's eloquent and inspiring address : "In the ever-renewing society what matures is a system or framework within which continuous innovation, renewal and rebirth can recur. For the self-renewing man the development of his own potentialities and the process of self-discovery never end".

"Naya Shikshak" Jan., 1966.

No Substitute for Hard and Serious Thinking

IT IS IMPORTANT to recognise that one of the characteristics of science is that things of quality need not necessarily be expensive. If enough thought is devoted it should be possible to have education of quality and yet 'cheap' enough to be within our means. Science brings today within the reach of common man things which at one time were not available except to the very rich. The same can apply to education, but to bring this about would need hard work and much serious thinking and research into the process of education. Lord Rutherford, the great pioneer of nuclear physics, said in the robust way of his, when he was told that America was going ahead in nuclear physics because they had a lot of money : "Americans have money. We do not have it, and so we have got to think". There is no substitute for hard and serious thinking; and with sustained and serious effort we should be able to go a long way even with our meagre resources and capital.

Man cannot fully know a doctrine if he has not rediscovered it himself and if has not repeated the demonstration himself. When a doctrine is only communicated by another person, there is not true learning in the recipient, unless he does reconstitute and remake it himself by his own ratiocination.

— Giambattista Vico

While India may not have a direct interest in space research or flights to moon or Mars and other planets, Science and technology are vital to a country where most of the natural resources are undeveloped or under-developed and where a rapidly increasing population is living often on the verge of starvation.

SCIENCE EDUCATION IN THE FOURTH PLAN

By

A. C. JOSHI

BEFORE ATTEMPTING to give an account of the various programmes likely to be taken up in the Fourth Five Year Plan for expansion and improvement of science education, it would be useful to consider why every country in the world, whether economically advanced or under-developed, is deeply concerned today with the problems of imparting good training in science. Why is it necessary to give science education today such importance? Why should science be included in the curriculum of the schools at all stages, right from the primary to the higher secondary and why continuous effort is necessary to increase facilities for science education and increase the number of seats for science students in the colleges and the universities? The reason is not far to seek. It is simply this that during the last hundred years there have been greater changes in the material aspects of the world and the human population than those that occurred in the entire previous history of mankind, and the pace of this change is continuously increasing. Further, all the significant changes that have occurred can be traced directly or indirectly to the impact of discoveries in science and the modern technology, which is in fact only the application of the scientific method and the results of scientific research to the problems of industry, agriculture, medicine, defence and administration. As a result, science and technology permeate now almost

every aspect of public and private life. They have had a profound influence even on the social system in every country. It has, therefore, become necessary for every nation to handle its affairs, both at the national and international levels, after taking full account of the scientific and technical considerations.

While India may not have a direct interest in space research or flights to moon or Mars and other planets, science and technology are vital to a country like ours where most of the natural resources are still undeveloped or underdeveloped and where a rapidly increasing population is living often on the verge of starvation. It is only by the cultivation of science and technology and their application to various problems that our economic future can be safeguarded. Science is necessary for reclaiming the badly eroded lands, for increasing the fertility of the soils, for raising yields from the fields as well as the forests, for industrial development, for improvement in the health of the masses and for proper planning of the rapidly exploding population. Hence, whether we like it or not, science has come to stay with us and from every point of view it must be learnt well. This does not mean that all citizens of a democracy like ours should be scientists, but it is necessary that everyone ought to have a good understanding of what science is, how it operates, what it can do and what it cannot do, and how it impinges on every aspect of national and international life.

The role of science in national development is well realised by Government and it has been stressed in the Science Policy Resolution of the Union Cabinet announced in 1958. According to this Resolution "the dominating feature of the present contemporary world is the intense cultivation of science on a large scale and its application to meet a country's requirements". The idea of a welfare state has grown out of a recognition of the possibility of providing every citizen with reasonable material and cultural amenities and services through the use of scientific knowledge. It is therefore one of the aims of the scientific policy of the Government to foster, promote and sustain the cultivation of science and scientific research and to encourage and initiate with all possible speed programmes for the training of scientific and technical personnel on a scale adequate to fulfil the country's needs in science and education, agriculture and industry and defence. The realisation of these objectives is to a great extent dependent upon the quality of educational system with particular reference to the provision for science education in schools and in institutions of higher learning.

Progress of science education in the First and Second Plans

A LARGE SCALE planned effort for the improvement of school science in India is of comparatively recent origin. Before 1947, both science education and technical education hardly received any special attention from educational authorities. As an instance of lack of appreciation of the importance of science in the school curriculum, one may mention that in 1887, the Government of India circulated a note on Technical Education by Sir Antony MacDonnel and drew the attention of the provincial Governments to the neglect which this type of education had suffered. This note divided technical education into the preparatory and the special branches. The preparatory branch was to have no connection with any particular industry or profession, nor was it to be distinct from ordinary education. Only drawing and elementary science were to be compulsory subjects in the middle and high classes of the ordinary schools. On the receipt of these recommendations, the Punjab Government appointed a committee to examine the whole question. This Committee made recommendations which, if adopted completely, would have involved the State in an additional expenditure of Rs. 50,000 per annum. Yet the Government was able to sanction only Rs. 10,000 and all that could be done was introduction of teaching of science in the high departments of a few anglo-vernacular schools.

After Independence, the study of 'Everyday Science' or 'General Science' was included as a compulsory subject in the school curriculum even from the primary stage, in most States, and the Secondary Education Commission (1954) strongly recommended the strengthening of science education as an integral and compulsory element in the schools. The Commission suggested that the pupils at the middle (upper elementary or junior or secondary) stage should be introduced "in a general way" to certain broad aspects of science. General science including mathematics should then be introduced during the first two years of the higher secondary course as one of the compulsory core subjects. A more intensive course was proposed in specific subjects like Physics, Chemistry and Biology for those who took science as an elective subject. In the light of these recommendations a programme for the introduction of elective science at the higher secondary stage was sanctioned in the last year of the First Plan, i.e., in 1955-56, in 214 schools. Provision was also made for improving facilities for science education in about 1100 other high schools at an estimated cost of Rs. 27 million.

DURING THE SECOND PLAN starting from April, 1956 and ending on March 31, 1961 a more comprehensive effort was made for the implementation of the recom-

mendations of the Secondary Education Commission, with reference to establishment of multipurpose schools, introduction of general science and elective science and upgrading of high schools to higher secondary schools. A scheme of science consultants was also formulated under which a specialist in science teaching was entrusted with the work of bringing about practical improvements in science teaching in a group of about 100 elementary schools by (a) trying out new methods, (b) discussing and demonstrating better teaching techniques, (c) improving teaching aids and (d) drawing up suitable syllabuses, etc. As a result of these programmes, there were established about 2310 multipurpose schools by 1960-61. Science as an elective subject had been introduced in about 5600 out of 17200 secondary schools. With the purpose of providing facilities for the development of inventive faculties of the students, about 450 science clubs were also set up in selected higher secondary schools by the end of the Second Plan.

In the matter of qualitative improvement of science education, the Second Plan undertook a review of the syllabuses in the context of the reorganised pattern of secondary education. Most of the State Governments and the All India Council for Secondary Education drew up integrated syllabi for middle and higher secondary stages, including the diversified fields of studies. A General feature of the scheme was the study of 'general science' as 'science in everyday life', consisting of a number of units around which the individual science subjects were sought to be integrated and developed. Visits to public utility services, botanical and zoological gardens etc. were to be organised as a part of science teaching. Demonstrations were to be incorporated in the lessons and the practicals were to follow class teaching. The students were to be encouraged to undertake project studies in groups.

Elective science offered in most of the States includes the study of physics, chemistry, biology, mathematics or geography. The standard aimed at this level is roughly of the previous intermediate classes and includes practical laboratory work. The detailed courses were developed with a view to help the understanding of the subject and include derivation of mathematical formulae from first principles.

In spite of the detailed guidance provided in the curriculum of science studies, the level of science teaching in practice fell short of optimum requirements for various reasons. Among these were the following :

(a) The teachers did not have sufficient general educational background and preparation to teach the integrated general science course in the way proposed;

(b) The amount of preparation and of practical work required for teaching general science included, for example, collection of natural history specimens by the

students, gardening, bee-keeping and other group project activities. All these could not be achieved due to physical limitations of time and human capacity;

(c) Deficiencies in laboratory facilities and difficulties of getting sufficient number of qualified science teachers; and

(d) Lack of standard books on general science and inadequate preparation for writing text-books in regional languages or for translation of standard books into the languages of instruction.

SIMULTANEOUSLY WITH THE EXPANSION of facilities for science teaching in schools, there has been a rapid expansion of facilities for science studies at the universities also in the post-Independence period. The enrolment of science students increased from 140,000 in 1950-51 to over 300,000 in 1960-61. The turn out of science graduates and post-graduates, excluding engineering, medical and agricultural students, registered an increase of 150 per cent during this decade, the number graduating in 1960 being over 26,300. The number of post-graduate departments increased from 363 in 1955-56 to 466 in 1960-61 as per subjectwise details given below :

Subject	No. of Post-Graduate Departments	
	1955-56	1960-61
Physics	56	71
Chemistry	60	83
Botany	52	64
Mathematics	75	90
Zoology	49	60
Geology	25	32
Geography	14	20
Anthropology	17	21
Statistics	12	16
Marine Biology and Oceanography	3	5
Astronomy and Astrophysics	-	1
Geophysics	-	1

As a result, the science enrolment in higher education increased from 27.3 per cent the total enrolment in 1955-56 to 30 per cent in 1960-61.

ONE OF THE SIGNIFICANT developments which has helped in a continuous review of standards of science education in colleges and universities has been the establishment of the University Grants Commission in 1956. In accordance with the recommendations of expert committees and visiting committees appointed by

the Commission the various Universities have been assisted in strengthening facilities for training and research in basic science subjects and also for establishment of new post-graduate departments. Assistance has been given also for improvement of science education at the undergraduate level by way of grants-in-aid for construction of laboratory buildings, purchase of equipment and library books and appointment of teaching staff.

It is estimated that about Rs. 200 million were spent on science education programmes during the First and Second Plans, including nearly Rs. 40 million given as grants-in-aid by the University Grants Commission.

Science Education in the Third Plan

IN THE THIRD PLAN, 1961-66, even a higher priority has been given to the development of science education. A new programme for science teaching in elementary schools aims at :

- Preparation of handbooks for teachers of science in modern Indian languages;
- Grants to teacher training institutions for equipping them with science laboratories; and
- Starting extension service to primary schools from teacher training institutions.

At the secondary stage the study of general science is being extended to as many schools as possible and elective science is being introduced for a much larger proportion of students and suitable measures are being taken for training of science teachers either through short-term in-service training courses or by expanding facilities for teacher education. The National Council of Educational Research and Training has set up four regional colleges of education which offer, inter alia, special teacher training programme for science subjects. Their departments of Science Education have initiated several projects for improvement of syllabi and text-books; preparation of supplementary reading material, science clubs and fairs; and science talent search. A Central Science Workshop has been started in New Delhi with assistance from UNESCO for developing students' kits, equipment and science apparatus and other aids required for the improvement of science teaching.

AS THE MAIN DIFFICULTY in rapidly expanding science education in schools is the non-availability of qualified teachers, it has been one of the major programmes in the Third Plan to increase the science enrolment in colleges and universities to over 5,50,000 by 1965-66. This in turn calls for concerted efforts to ensure

a large number of qualified teachers in the universities and colleges, estimated at 17,000 for the Third Plan period. In order to meet this demand the University Grants Commission has accorded high priority to the strengthening of post-graduate teaching and research. With a view to do so in the most effective way, the Commission has formulated a scheme for establishment of Centres of Advanced Study in selected Universities. Under this scheme, a limited number of University departments are being developed for advanced training and research in certain fields. The scheme is intended "to encourage the pursuit of 'excellence' and team-work in studies and research and to accelerate the realisation of "International standards in specific fields". So far 26 such centres have been set up in 12 universities with technical assistance of UNESCO. Of these 26 centres, 13 are for science subjects, 3 each in Physics and Chemistry, 2 each in Botany, Zoology and Geology, and one in Astronomy. Technical assistance for this scheme includes the provision of services of experts from abroad, equipment and books as well as training facilities abroad for Indian teachers.

NO SYSTEM OF EDUCATION can rise above the level of the teachers who man it. The greatest weakness in the improvement of science education in the country has been found in the lack of adequately qualified teachers in sufficient number, both for high schools as well as colleges. It was, therefore, felt that the quickest way of bringing some improvement in science teaching would be to provide proper refresher courses to teachers already working in schools and other institutions. The need for providing refresher courses in order to improve the competency of teachers in the secondary schools, both in content of selected subjects and methodology of teaching, was specially stressed by the Secondary Education Commission in their report. The All India Council for Secondary Education, which was set up by the Ministry of Education soon after the publication of the Report of the Secondary Education Commission, started several in-service programmes for preparing teachers both in the old and the newer subjects of the school curriculum. Such programmes were arranged by the Council sometimes directly under its own auspices as well as through the agency of the Extension Services Departments which were established in several training colleges. It was, however, soon realised that such programmes (refresher courses & seminars) were of too short a duration to make any significant impact on the quality of teaching. Further, there was lack of follow-up action. In 1963, it was decided to carefully assess what was being done for the in-service training of teachers in other parts of the world. Impressed by the Summer Institutes Programme of the U. S. National Science Foundation, a similar programme of refresher courses of 6-8 weeks duration during the summer vacations was taken up here as

well in 1963 by the UGC and NCERT, both for high school science teachers as well as college and university teachers. In the first year (1963) only 4 summer institutes were organised by the UGC but the number was rapidly stepped up in subsequent years. During 1964 and 1965 the number of summer institutes organised was 44 and 94 respectively, and the number of teachers who attended these institutes was 1940 and 4690, compared to 160 of 1963. The distribution of the teachers who have undergone these courses in the Third Plan period according to their subjects of study is shown below. This does not include 1440 teachers of engineering colleges and polytechnics.

Subject	Secondary school teachers	College teachers	Total
Mathematics	1000	550	1550
Chemistry	800	550	1350
Biology/Zoology	550	550	1100
Physics	800	550	1350
Total	3150	2200	5350

The Third Plan provides for an expenditure of Rs. 115 million for establishment of multipurpose schools and for expansion and improvement of science education in schools and institutions of higher learning. This is exclusive of provision relating to revision of salary scales of teachers etc. The actual expenditure is expected to be more than the provision by about Rs. 5-6 crores.

A review of the progress during the past fifteen years.

BEFORE CONSIDERING THE PROPOSALS for the Fourth Plan it would be worthwhile to review the progress made in regard to science education during three Plan periods so that measures for obviating existing shortcomings and difficulties could be identified and remedial measures adopted in the Fourth Plan. For this purpose, reference may be made to the surveys, analyses and reviews conducted by the Government departments, National Council of Educational Research and Training as well as to the reports of the Indian Parliamentary and Scientific Committee on Science education in schools and of the UNESCO Planning mission on Science and Mathematics Education in Schools.

Although science is being taught in some form or another from the primary classes, it is observed that the content of science education varies from State to

State. Out of 23,900 high/higher secondary schools expected to be functioning by the end of the Third Plan, hardly 9000 schools, i. e. less than 40 per cent have introduced elective science; and out of these, hardly one school in every five has adequate laboratory facilities. According to the Panel for Science Laboratories and Equipment of the Committee on Plan Projects (Planning Commission, 1962), among a number of higher secondary schools in Delhi, Roorkee and Dehradun, "while a few schools had reasonable well-equipped laboratories for science subjects, the condition in others was far from satisfactory. The laboratories were overcrowded and lacked equipment and furniture. The enrolment for the subjects was beyond the capacity of the laboratories". In regard to teachers, they found that in most science laboratories only one teacher was available and he was hardly able "to do justice to the personal requirements of the pupils". A survey carried out in Madras by the South India Teachers Association led to the same conclusions.

In regard to the content and method of science education in schools, the UNESCO Planning Mission in their report on "Science and Mathematics Education in schools in India" have observed that science education at present does not meet the needs of scientific and technical tasks involved in planned development of the economy. The Indian Parliamentary and Scientific Committee pointed out that the present curriculum in science subject was out of date and needed to be modernised on a continuing basis. According to them, science should be compulsory for all students in the form of subject disciplines such as Physics, Chemistry etc. so that every student who leaves the school should be equipped with elements of science—also of humanistic culture—whatever be his post-school activity in employment or in continuation education.

The present position of science education in teacher training institutions is not very different. According to a recent survey of the National Council of Educational Research and Training, out of 84 training colleges included in the survey, 53 per cent colleges had science laboratories, but out of them only one-third had sufficient apparatus to teach Physics, Chemistry and Biology of the high school standard. In regard to teaching hygiene and physiology, not more than 10 per cent of all the training colleges provided the necessary laboratory apparatus. At the training schools for elementary school teachers, it was observed on the basis of data from 138 institutions that only 67 per cent of science teachers had the required academic qualifications. Laboratories were available in 41 per cent of the institutions, but these were not sufficiently equipped with apparatus for performing even simple experiments based on the syllabus for elementary schools.

Thus it has become clear that the major tasks for expansion and improvement of science education in schools during the coming years should include identifying the aims of science teaching in Primary and Secondary schools, measures for reviewing courses of studies, training of science teachers including refresher courses, preparation of text-books, demonstration and laboratory apparatus, preparation of teaching aids and introduction of a comprehensive scheme for reorganisation and strengthening of existing facilities.

Proposals in the Fourth Plan

THE FOREGOING ACCOUNT of developments during recent years makes it clear that if the nation is to derive full benefits which accrue from the acquisition and application of scientific knowledge, science education has to begin at an early stage in a child's schooling and to continue with a deepening content throughout the secondary stage. At the university stage, it should become more intensive for those who join the science faculty and should include high quality research work. It is also clear that we are far from this goal and there are great weaknesses in our programmes of science education at all stages. In the Fourth Plan it is proposed to make a bold effort to overcome these weaknesses and strengthen the teaching of science both in elementary and the secondary schools as well as in the colleges and the universities. This is specifically mentioned in the Memorandum on the Fourth Plan published by the Planning Commission and within the available resources adequate financial allocations are being made to move rapidly towards the proposed goal.

PROGRAMMES OF SCIENCE TEACHING at the elementary stage would aim, among others, at the following :

- (i) development, in a general way, among the students of primary classes, an understanding of the physical and social environment and the forces and causes governing various natural phenomena;
- (ii) development of new methods of teaching so as to relate science to one's environment and train the students in accurate observation and problem solving techniques of science; to inspire the students by including in the curriculum science subjects, in the form of stories, lives of great scientists, etc;
- (iii) Setting up of mobile audio-visual units with film projectors which could exhibit short films on various aspects of science to the elementary school students. The films could deal with such subjects as improvement in agricultural practices, nutrition, hygiene, health, flora and fauna of the country, simple scientific principles and some of the major discoveries of the present;

(iv) to make serious attempt at the middle stage of education to improve the quality of instruction in general science or various science subjects as the school may choose.

AS FAR AS SECONDARY SCHOOLS are concerned, according to a memorandum approved by the Conference of Education Ministers in May, 1965, the programmes of strengthening of science teaching would take the following form :

(a) compulsory study of General Science would be introduced in such schools where it has not been provided so far, so that all the students completing secondary stage would have studied science;

(b) in existing schools, where general science has already been introduced, it would be adequately strengthened;

(c) elective science should be a subject at least in one school in an area so that students desirous of going in for higher education in science are able to study the subject at a higher level; and

(d) every school should have a small library of science books and some standard scientific journals.

THE PACE OF THE PROGRAMME of strengthening of science education, both at the elementary and the secondary stages, would, to a great extent, be determined by the availability of (a) trained teachers; (b) scientific equipment; and (c) text-books, reading material and literature. The following steps are visualised to meet the situation.

There is considerable shortage of science teachers in the country and this will be accentuated by further expansion during the Fourth Plan. The various programmes proposed to step up the supply and training of science teachers are :

(a) The regional colleges of education would train science teachers in much larger numbers.

(b) The existing teachers will be provided in-service training in the summer institutes after they have gone through correspondence courses. In addition to summer institutes, which are being organised with the help of Usaid and which provide short-term training to about 2,000 teachers annually, it would be necessary to organize a larger number of summer courses so that on an average about 7000 to 8000 science teachers are given training every year. Correspondence courses will have to be provided as a major means of training teachers in science and if the science courses are integrated with summer institutes it would be possible to arrange

for personal contact between the teacher and the university faculties which is essential for the effectiveness of correspondence courses.

(c) The supply of science graduates and post-graduates would be increased in order to meet the existing shortages and future requirements. This will require immediate action in those States where supply of science graduates and post-graduates is inadequate. The University Grants Commission, the Universities and the State Governments will have to include necessary programmes in the expansion of higher education.

(d) Telescopic and short-term programmes would be arranged for the existing under-qualified science teachers for improving their qualifications.

(e) One institute of Science Education will be set up in each State.

(f) The existing training colleges will be strengthened in terms of their laboratories and teachers for training science teachers. There will also be increased accent on science content in teacher training institutions.

(g) The existing extension service centres of training colleges would be strengthened for arranging seminars and workshops for science teachers and new centres would be established.

(h) A concerted research programme in science education for providing necessary periodical guidance to teachers in new methods and techniques will be developed.

The requirement on account of scientific equipment for all sectors of education including technical education estimated for the Fourth Plan is about Rs. 2520 million. For schools and colleges of general education the rough calculation may be of the order of Rs. 1000 million or so. This is a huge demand and attempts will have to be made to arrange for a phased programme of production of equipment from indigenous sources. The Planning Commission has already set up a Working Group to go into the various problems relating to scientific equipment at all stages of education. The report of the Working Group would help in making rough assessment of the demand of scientific equipment in relation to our existing capacity and recommend concrete programmes for bridging the gap between the requirements and the availability of equipment, if necessary.

As far as equipment for secondary schools is concerned, the Planning Commission Committee on Plan Projects' Panel on Science Education in Secondary Schools have suggested that it would be necessary for each State to plan their approximate needs of laboratory equipment on a long-term basis in accordance

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with the proposals embodied in their Plans. This would enable the State Governments to meet their requirements sufficiently in advance. Teachers' training institutions will have to be provided with appropriate workshops to improve the necessary skills of the prospective science teachers. The administrative procedure in regard to scrutiny of requirement of science equipment and its supply to schools would have to be streamlined. State Education Departments may make purchases for scientific equipment on State/regional/district basis till such time as the purchase specifications are laid down by the concerned authorities in the interest of ensuring quality products at reasonable prices. It would be possible for the Central Science Workshop of the National Council of Educational Research and Training to evolve designs and prototypes of apparatus required both for demonstration in the class by teachers and experimental work by the students.

In regard to the preparation of suitable reading material, textbooks and literature in science subjects, the National Council of Educational Research and Training have already taken necessary steps. Model textbooks and materials would need to be translated in various regional languages. The science syllabi will have to be improved to incorporate modern developments. Method guides for teachers to assist them in teaching science on sound line will be developed.

The scientific talent among students will be identified and promoted through such programmes as the establishment of the district science education centres, science museums, science clubs, science fairs and other activities. The scheme of science talent search will be intensified in the Fourth Plan.

To enable the State Directorates of Education to take an integrated view it has been recommended by the COPP Panel on Science in Secondary Schools that a separate branch of science education in the State Department of Education, under a qualified special officer of the rank of Deputy Director, be created. This Officer should be assisted by Science Supervisors at the district level to ensure proper standard of science teaching.

Tentatively in the Fourth Plan, a sum of Rs. 500 million has been provided for various programmes of strengthening of science education in existing schools and introduction of science courses in new schools. This is in addition to a provision of nearly Rs. 100 million for the programmes of NCERT. In view of the magnitude of the problem it would be necessary for each State to draw up a comprehensive Plan of development for science education in terms of the requirements of personnel, equipment, books, literature, etc. in a phased manner. In this connection, it may be useful to have a project approach for the development of science education so

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that precise year-wise details of each input are worked out by each State. This would assist in initiating action at various levels. It is expected that these steps envisaged during the next 5 years for development of science education will generate an adequate potential for a large scale growth of science in schools.

AT THE UNIVERSITY STAGE, the progress made in science education in terms of student enrolment since Independence is on the whole satisfactory. There is, however, a wide spread feeling that with this quantitative expansion quality has suffered considerably. In any case the standards attained, both at the undergraduate and post-graduate stages, are not what we would wish them to be. We have to make a great leeway in qualitative improvement of the undergraduate courses. This programme as well as the need to strengthen post-graduate education in various scientific disciplines as well as research will be accorded a high priority in the Fourth Plan. Provisionally a sum of Rs. 1340 million has been earmarked for university education, excluding funds specially earmarked for higher education in agriculture, health and technology and about Rs. 600 million for scholarships. It is expected that a large part of this allocation will be spent primarily on extending facilities for expansion and improvement of science education. In addition to this provision, a sum of Rs. 150 million is being provided for the training of research personnel. About half of the funds earmarked for university education would be channelled through the University Grants Commission who would continue to make sustained effort for the improvement of standards of higher education in every field.

In conclusion, it could be stated that it is proposed to give a positive lead during the Fourth Plan in the Matter of science education at all stages, both as an important tool in the cultural development of the people as well as to meet the scientific manpower required for the development of a self-reliant economy. Under National Emergency, uncertainty about certain matters has delayed, to some extent, the working out of the details of some programmes.

The task is expected to be taken up in the coming months. The targets contemplated for the Fourth Plan, however, are the minimum that we have to achieve, if we have to make some progress in the field that is characterised by rapidly expanding boundaries. The responsibility for implementing various programmes will fall largely on the State Departments of Education and the Universities. It is hoped that they will set up without much delay an efficient administrative machinery required for the implementation of these programmes and will reach the goals set before them so that an era of scientific and technological progress is ushered in the country without further delay.

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TEACHING of Science at various Levels

BY R. C. MEHROTRA

IN THE MODERN AGE OF SCIENCE AND TECHNOLOGY, the importance of science education and training of scientific personnel is receiving the foremost attention all over the world. In a less developed country like ours the question assumes an overall importance as our material progress as well as national security are intimately related to the number of well trained scientists available and their efficiency to handle successfully the multifarious problems which face the country at the moment. The question has assumed even a more urgent form in the present crisis facing our country. However, apart from the needs of scientists in the special situations of our country today, the subject is of universal interest. In a situation somewhat similar to what faces us today, A.N.Whitehead wrote in 1916, "In the conditions of modern life the rule is absolute : the race which does not value trained intelligence is doomed. Not all your heroism, not all your social charm, not all your wit, not all your victories on land or at sea, can move back the finger of fate. Today we maintain ourselves. Tomorrow science will have

To cope with the phenomenal advances in science and the needs of the country the syllabi and the teaching of science at all levels need our immediate attention. Science education at lower levels should not be just a preparation for higher levels, but should provide sufficient training for full employment at each stage.

moved forward yet one more step, and there will be no appeal from the judgment which will then be pronounced on the uneducated".

THE TRUTH OF WHITEHEAD'S STATEMENT is even more apparent today than it was in 1916 ; recently this very passage was quoted in the report of a Scientific Advisory Committee established by President Eisenhower to 'set forth national goals for strengthening science and engineering education'. In this country also the importance of science education and training of scientific personnel has been fully realised in the context of the present age of science. This is reflected in the following aims of the Scientific Policy Resolution adopted by our Parliament in 1958 :

"(i) to foster, promote and sustain by all appropriate means, the cultivation of science and scientific research in all its aspects—pure, applied, and educational ;

(ii) to ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognise their work as an important component of the strength of the nation;

(iii) to encourage, and initiate, with all possible speed, programmes for the training of scientific and technical personnel on a scale adequate to fulfil the country's need in science and education, agriculture and industry and defence;

(iv) to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity :

(v) to encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge in an atmosphere of academic freedom; and

(vi) in general, to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge."

The Government of India have decided to pursue and accomplish these aims by offering good conditions of service to scientists and according to them an honoured position by associating scientists with the formulation of policies, and by taking such measures as may be deemed necessary from time to time.

Number and Quantity of Scientists

THE TOTAL NUMBER OF STUDENTS enrolled in science subjects in all the Universities and higher colleges in the country has risen from about one hundred thousand in 1947 to about four hundred thousand last year. In spite of this rapid rise in the numbers, the requirements of the country demand that the number of our M.Sc.s be increased at least fivefold immediately. For example, our output of M.Sc.s is about the same as the number of doctorates in science in U.S.A. With the increasing research fellowships and facilities provided in the Universities for research work, the number of research scholars is gradually on the increase but nearly the four hundred Ph.D.s in all Science subjects being produced annually by Indian Universities fall far short of our present requirements.

AS IS APPARENT from the above facts and figures, we require a very rapid expansion of our teaching and research facilities to cope with the large number of teachers and trained investigators required in the country. However, even a more important aspect of the problem is the improvement of the quality of our graduate and post-graduate students. It is only during the post-independence era in the country that sufficient avenues are available for the employment of the trained personnel appropriately in the discipline in which they have received their education. Prior to independence the only services available to brilliant graduates were the administrative civil services irrespective of the faculty in which they were trained. Happily the position has been altered completely for the students of science and this fact has to be brought home to the young student very clearly and emphatically. It is to be impressed upon the science student that whereas for his predecessor in the University about two decades earlier, it did not matter much whether he had assimilated the knowledge well or not. All that mattered was that he should have crammed the information and should have developed a capacity to reproduce it

well enough at the University or the Public Examination to get either a high division or entry into a senacure service. In these services his real knowledge in the subject was never put to a test. This position fortunately no longer holds good today. For working and making a mark in the profession of science, the person is called upon to apply his available knowledge from his own storehouse and in the performance of his duties, the crammed information is not of much avail any longer. Unfortunately the changed times and circumstances have not been fully appreciated by our institutions and hence, we are still continuing in most cases with the outmoded systems of instruction and examination only.

Training and Specialisation

ONE OF OUR PROMINENT SCIENTIFIC THINKERS, Michael Polanyi, recently remarked that the professional standard of science must impose a framework of discipline and at the same time encourage rebellion against it. This dual function is but the logical outcome of the belief that scientific truth is only one aspect of the reality as understood presently but the orthodoxy of science should be taught as a guide that should enable the novice eventually to make his own contacts with this reality. The capacity to renew itself by evoking and assimilating opposition to itself appears to be logically inherent in the sources of the authority wielded by scientific orthodoxy. To train the young people in this dialectic between orthodoxy and dissent is the very difficult job confronting the science teacher of today. An interesting experiment tried in a number of American Universities during the last year or before that appears to have brought forth promising results. In this new scheme, brilliant young high school students are attached to important research atmosphere but many a time they are also asked to tackle a simple research problem themselves. Even during ordinarily teaching in the terms, the students are being encouraged more and more to learn and assimilate the subject by carrying out experiments, making their own deductions and thus developing an insight into the subject rather than learning the whole mass of data and theories from a written book. There is constant research going on in these directions and new text-books on these lines are being written and tried even for school stages by top-authorities including some Nobel Laureates in the subject concerned.

ANOTHER ASPECT OF SCIENCE EDUCATION which demands our attention is the stage at which specialisation in studies should begin. An important feature of the present day developments in Science is that although the areas of investigation are getting narrower and narrower, the techniques employed by the scientists are

getting wider and wider so that the successful investigator in a particular specific subject of Botany or Zoology is not only expected to know his own branch but he has to be proficient in a number of other disciplines such as Chemistry and Statistics to be able to follow the bio-chemical reactions involved and to be able to draw statistically correct conclusions from his varied data. Requirements such as these have recently brought forth revolutionary changes in the systems of instruction in the more advanced countries. For example in the new University of Sussex established last year in U.K., the teaching of Physics, Chemistry and Mathematics is not compartmentalised into separate Departments but is planned to be carried out as an integrated whole under a common school of Physical Science. A few months ago a similar experiment was initiated by the University of Cincinnati in U.S.A. for their Ph.D. course. Some moves in this direction are fortunately afoot in one or two Universities in this country also but these have to be strengthened and expanded rapidly for the requisite type of training to be imparted to our young student.

The extent of specialisation at various stages of the pyramid of education requires careful consideration from another angle. As Dr Kothari has stressed, the universal experience is, that broader the base of this pyramid, the easier it is to get adequate numbers of well trained personnel at the highest level. However, it should be possible to withdraw some persons at convenient stages from the mid-points of the pyramid and let them be employed gainfully in various types of jobs. Science education at lower levels, therefore, should not be just a preparation for higher levels, but should provide sufficient training for full employment at each stage. These two differing basic aims often impose some difficulties for planners of education. The first one generally requires a thorough gradual grounding in the basic fundamentals of science as a whole with need for specialisation arising quite near the top, whereas the second one requires professional orientation of some sort at various levels. The lack of latter possibility in an adequate measure in this country has led to overcrowding in our higher institutions in contrast to the situations in U.S.A., U.S.S.R. and U.K. The best solution appears to be the establishment of polytechnics and professional institutions in which students well trained in the fundamentals of sciences may be given some applied bias suited to the industry which they are choosing to serve.

Expansion of Science

THE ADVANCES IN SCIENCE are occurring the world over at a phenomenal rate which is exponential in nature with a doubling period of about 12 to 13 years.

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This feature has begun to worry the conscientious teacher rather seriously during the last decade or so. As a result of this exponential growth, the experienced teacher who began his career in the early thirties finds that today the rate of new knowledge being added per year is commensurate with the total amount of world knowledge in his subject which was available as a whole when he began his career. Naturally the problem would gradually become even more serious for the new teacher who is beginning his career today. These circumstances clearly underline the great need of refresher courses and good review articles to keep the teacher of all stages abreast with the fast rate of expanding scientific knowledge. Another important requirement which has been brought to the forefront by this exponential growth of knowledge is the change in our syllabi. It is of course getting almost impossible to go on compressing the fastly increasing amount of new knowledge within the short span of three to five years which the student spends at the University and, therefore, for the framers of the syllabi a judicious selection has become an imperative need of today. The University Grants Commission realising the importance of this requirement had constituted all India Committees to go into the different aspects of this problem subject-wise and suggest essential changes and requirements. This has to be a continuing process and there appears to be a need for reconsidering the syllabi already recommended by these committees; the U.G.C. appears to be aware of this and has already restarted the process in Mathematics.

Foreign Training and Competition

KNOWLEDGE AND LEARNING ARE and have been all through the ages a universal phenomenon. The advances of science have brought the world together not only in the literal sense of space but also emotionally. There is a keen worldwide competition and co-operation in the fields of science today. Attracted by much better facilities and emoluments available in more advanced countries, a large number of our trained students of science are proceeding abroad for further training. Many of these young men, finding the atmosphere of the foreign laboratories much more congenial and conducive to better work, are tending to settle there in their new surroundings.

It is the confirmed opinion of all concerned that basically our student is on the average in no way inferior to his counterpart in any part of the world. The highly creditable and favourable impression created by our students abroad makes them generally very welcome in these countries which are all feeling a shortage of scientific personnel in the present fastly moving era of science and technology. Although

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this should not have mattered in the larger interest of the world as a whole. Yet this one-way traffic only is presenting a serious problem before our planners who have been emphasizing the acute shortage of personnel already for most of our plans of development. The Government of India has started a Scientific Register where a record is kept of our scientists abroad and is trying to attract them back by all possible means and this policy is bringing fruitful results already. It should be a matter of serious enquiry why these young people, who are able to do such creditable work in the foreign laboratories, find themselves at a loss in their own surroundings. This may require some drastic changes in the set-up of our academic hierarchy but we must make a sincere and positive effort to retain these people by giving them proper conditions and facilities for work. With this aim in view, it may be worth the effort and expenditure to set up a committee of people like Dr Singhwi and Dr Harish Chandra, who had to return back after a serious effort to settle down in our laboratories along with some persons like Dr Khurana who have continued to work in foreign laboratories and some brilliant younger workers, who, in spite of several attractions and invitations from abroad, have continued to toil in our own institutions in spite of these handicaps.

Even if some of these scientists are not willing to return permanently, they may be induced to come here on short contracts to train younger workers in their own settings. This latter aspect is rather important and requires our general attention. While we should not put a stop to our young scientists going abroad for higher training in certain specialised fields, it would be much better if we could attract the top specialists to our laboratories even for short terms at a time to plan the facilities here and train the younger scientists in an atmosphere in which they could continue to struggle further and grow. The contrast between the facilities available in well equipped laboratories outside and our laboratories is so depressing that our young scientists returning after a period of training abroad find themselves lost and too frustrated from the very beginning. The most important step we have to take is to make our scientist feel welcome and to allow him adequate facilities for work in an atmosphere free from too many irksome administrative controls.

THE PHYSICAL FACILITIES of equipment require considerable strengthening in our institutions not only for the research and post-graduate students but at lower levels also. The equipment available in our colleges for scientific experiments by students and even for demonstration by teachers is really very unsatisfactory and meagre and requires immediate attention. The conditions obtaining in the schools

in these directions are even much worse. Apart from this, what is even more important is the creation of a spirit of true scientific curiosity and enquiry in all our educational institutions. A clear realisation of the important role awaiting our science students in the reconstruction and development of the country goes a long way in fostering that spirit of dedication and devotion which is essential for the growth of a truly scientific atmosphere.

Suggestions For Various Levels

IT IS OBVIOUS THAT THE PIVOT OF PROGRESS in any teaching programme is the 'teacher' and unfortunately we have neglected our school teacher too miserably. Conditions of service, facilities for teaching and amenities for self improvement provided to this class of teachers, all require

(1) SCHOOL EDUCATION our most urgent and immediate attention. Fortunately, a preliminary step has been taken for the last point by the organisation of the Summer Institute programmes in the country. For any movement to be effective in this fastly changing world of concepts and ideas, it is essential that the number of individuals involved should reach a 'critical' stage quite early and this requires acceleration of the Summer Institute programme at a much faster rate. We may emulate in this direction, the example of Japan where Seminars for science education are being arranged with the objective of retraining of 10% of all elementary and 50% of all secondary school teachers in five years.

In spite of some planning not much tangible effort seems to have gone towards the essential 'follow up' programme for teachers exposed to new materials and techniques at these Institutes.

The equipment facilities in the schools have to be strengthened considerably. There is no need to go in for very costly or imported apparatus. "Source Book for Science teaching", published by UNESCO can be a useful guide in this direction. In fact, the workshop facilities in the schools should be strengthened and in most of the cases it should be possible for the simple equipment required in the elementary classes to be fabricated either by the students of the same class or those of a higher one. There is no doubt that the most serious single drawback in our training of scientists and technologists is the lack of proper workshop training and a general apathy towards manual work. This has to be remedied at all levels and workshop practice and training should not be treated as an ancillary 'chore' to be given up as time for more serious study approaches near the examinations, but these should form an integral (and at least for some time, an emphatic) part of the educational system.

IN SUGGESTING ANY IMPROVEMENTS for this stage, one must be realistic about the enormity of the problem facing us. In 1960-1961, we had about 35 million students of the age group 6 to 11 in primary classes and this number should have risen to about 50 million by the current year, requiring the services of about 1.25 million teachers. It is a staggering problem to be able to train all these teachers even to a minimum level of proficiency. We have in the meantime to think of supplementary aids. U. S. S. R. faced the same problem, but they have been so highly successful in the field that it may be worthwhile for us to take lessons from their experience. In this direction, the following remarks of a senior English science master John L. Lewis who visited U. S. S. R. in 1961 are worthy of our attention :

"Though there are sufficient teachers for the schools, I was repeatedly told there were not enough really good natural teachers. They accept this will always be the case and set out to ensure that the indifferent teacher has sufficient guidance and sufficient material (apparatus, films, etc.) to ensure that he gives a good lesson".

A MAJOR PORTION OF LOAD at this stage would have to be borne by our Degree Colleges affiliated to different Universities. These institutions are managed and financed either by State Government or by private committees. Unfortunately, neither of these agencies appear to have realised that without the provision of at least the barest minimum facilities, proliferation of such science colleges is a definite disservice to the society. Fortunately, most of the basic equipment essential for undergraduate teaching and demonstration is being manufactured in the country and hence, the problem can be easily tackled with the help of better finance and planning.

Efforts are already afoot to lay more emphasis on basic understanding of the fundamentals rather than cramming a lot of descriptive data. In view of the dependence of any quantitative science on mathematics, proper training of every science student in rudiments of mathematics is absolutely essential. The current practice in a large number of universities of allowing Zoology, Botany and Chemistry (along with options of Geology or Geography also in some instances) as combinations alternative to Physics, Chemistry and Mathematics requires an early modification. What was true about dependence of Physics upon Mathematics two decades ago has become applicable for almost every discipline of Science today. The teaching of Mathematics itself requires drastic changes. In many instances, branches of mathematics are taught also in the chronological order in which they

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have been dealt. This may be true for other disciplines also, but at least in the science of mathematics, many later techniques like group theory or topology, although developed later, give simpler and more direct approach to much vaster area of knowledge. Fortunately many of these are easier to teach and there is no reason why they may not form an early part of the teaching programme.

THERE ARE NUMEROUS OTHER FACETS of the problems, but I shall confine my attention to one other aspect only—teaching of languages and General Education at this stage. It is in the field of language that standards of the undergraduate student have fallen miserably in recent years, and without proper command of this essential medium, the teaching and learning processes are bound to be most limited and defective. The matter deserves more active consideration at lower stages, but till this is accomplished, some courses in this direction are essential at the undergraduate level also. These courses should be as practical as possible and should aim at teaching primarily the language to the student as a means of communication and expression. Further, it is desirable to concentrate these courses in the earlier part of the undergraduate programme leaving the latter part mainly for the main subjects.

Regarding General Education in a stage of the world where the development of 'Two Cultures' has become a burning and frightening topic of discussion, the importance of this aspect of education cannot be over-emphasized. However, the perfunctory manner in which this important subject has been dealt with so far has done a greater harm than good and it is imperative that the subject be dealt with by teachers of greater originality and experience, capable of synthesising the various aspects of human knowledge into a coherent whole, rather than by novices who are considered not fully qualified for teaching even their specific discipline.

A MAJOR LOAD OF THIS STAGE of education should be borne by the Universities. Teachers at this stage should not only be trained in research methods, but should preferably be active researchers themselves.

(3) POST-GRADUATE EDUCATION In this context, only such institutions should be raised to the post-graduate level where at least a minimum amount of facility for research can also be created simultaneously. Without this, these post-graduate colleges will not be able to attract talented teachers suited to this level. This point appears to be worthy of consideration for the fastly growing Technical institutions and Regional Colleges of Engineering and Education which, in spite of even higher grades, have been experiencing this difficulty. (It may be mentioned here, in passing, that this aspect of higher vogue within the last

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few years only requires our immediate attention. Unless the situation is remedied, the standard of basic and fundamental sciences would tend to fall).

The following points require our special consideration in connection with post-graduate education :—

(i) **SYLLABI :** A mention of this has been made in the introductory portion of the statement also. While the central committees of the U. G. C. should indicate the broad lines of syllabi, the various institutions should be given an autonomy, rather they should be encouraged to develop some courses specifically suited to the talent available with them. There would be considerable difficulties in this. However, if the actual teacher could be given a chance to formulate his own syllabus (may be within a general framework), this would immediately bring about a revitalisation of our whole system and induce a healthy competition, conducive to better growth.

It may be pointed out that the syllabi of practical work require even a much greater attention. The present practice of prescribing a few experiments to verify known results and frequent repetition of the same type of experiment to make the student better equipped for a similar exercise at the examination creates, instead of interest and enthusiasm, an abhorrence for this type of training. Just as a matter of illustration, I might select my own discipline "Inorganic Chemistry" and reproduce my statement at the First UNESCO Seminar of South-East Asia Countries in 1960.

"When we look at practical courses in Inorganic Chemistry in our Universities, there is a cause of much greater concern. At most of the places, the practical work in qualitative Inorganic Chemistry through the five or six years of training period after matriculation examination, merely consists in the analyses of more and more complex artificial mixtures containing the possibility of a larger number of basic and acidic radicals. The surprising fact is that in most of the Universities, no emphasis is laid at all on training the student even in dealing with semi-micro quantities, nothing to speak of the micro or lower scale. The only thing which the students could be expected to achieve by such repeated practices is a possible skill in the automatic use of and often a hatred and disgust for the qualitative separation charts. These artificial mixtures unfortunately have little bearing or relationship to the commonly occurring chemical systems. The same remarks, more or less, apply to the quantitative aspect of analysis. Naturally the student after doing his B.Sc. (Hons.) or M.Sc., finds himself absolutely lost when he is confronted with an ore, or say, steel sample for analysis as his first job in an industrial concern.

Thus, the practical courses require a complete overhauling. The training in group separations and individual identifications or quantitative separations have a rightful place in the courses of practical chemistry, but it should be clearly and widely recognised that their main aim should be to teach principles of the unit operations. 'Substances for analysis should be chosen for the technique which they teach, rather than as illustration of types of compounds'. Further, the student, should be encouraged to develop his own scheme of analysis for an ore or some other natural sample after its qualitative detection has been completed. The students should be trained to deal with smaller and smaller quantities of materials even in the classical schemes of separation. Sufficient practice should be given in the techniques of micro-analysis. The student should also be familiarised with the physico-chemical methods of analysis so that he begins to realise the directions in which the whole scheme of analysis is tending to move.

APART FROM QUALITATIVE AND QUANTITATIVE ANALYSES, sufficient emphasis should be placed on teaching the techniques of Inorganic Chemistry. Most of our M.Sc. students have a dread of dealing with a sealed bottle of titanium tetrachloride, or dealing with a spontaneously inflammable substance like aluminium alkyls. Handling of substances out of contact of air or moisture must form an essential feature of all our practical courses. Further, synthesis of simple and also complex compounds and their purification by classical as well as modern physico-chemical methods should form an essential feature of the practical course. After purification, the students should be encouraged to test the purity and study a few physical properties also of the compound synthesised. With a little foresight and planning, work of the above type can be given as a very elementary research problem and the student should be encouraged to take part in it as an active participant".

(ii) **INTER-DISCIPLINARY CO-OPERATION :** Even if we are not prepared for a complete merger on the pattern of the experiment (mentioned above) being tried at the new University of Sussex, there is an urgent need for active inter-disciplinary co-operation in view of their merging boundaries today.

Apart from day-to-day work, special emphasis should be laid on holding Vacation Schools in such border-line areas.

(iii) **SESSIONAL WORK :** In order to ensure that the learning process is continuous and not limited to cramming during the last few weeks before the actual examination, the practice of assessment of session work has to be started with full vigour. Some of us have had a personal experience of running a scheme of this type at the University of Gorakhpur for two years and in spite of serious limitations,

the scheme was bringing forth definite and unequivocal improvements when it was given up (unfortunately under temporary pressure from a few undesirable students, to whom the scheme could not obviously appeal). The experiment is being again attempted in a very cautious manner at the University of Rajasthan, but much can be learnt by the experience of the I.I.T., Kanpur where a detailed programme of this type has been initiated.

(4) RESEARCH : Professor D.S. Kothari, in his presidential address to the Jubilee session of the Indian Science Congress, remarked "The experience of more than a century, beginning with the great German Universities, has clearly shown that teaching and research flourish best in combination : in isolation they both wither. The best of either is achieved in an environment where both are cultivated. In this combination of teaching and research, education and discovery, lies the real strength of the Universities". Apart from this, basic research for its own sake has become a very important function of our Universities. In spite of the establishment of a number of National Laboratories and Research Institutes (general as well as specialised), Universities remain the most fertile spheres for "Pure Basic" research in science subjects. This point has been brought out in the following words by a Review Committee of the C.S.I.R. which submitted its report only recently :

"Pure basic research is important to India for several reasons. It is the principal source from which major departures from orthodox practice arise. By its very nature such research must be up to world standards and the firm establishment of such standards in India is essential to the maintenance of a high level in all types of research. Finally and perhaps the most important reason concerns teaching. University teachers train people for the future and their students not only must know what the proper standard of research is but must also be, in some fields at least, thoroughly up-to-date. This is one primary reason why pure basic research and universities are normally found together. The other is that pure basic research thrives better in the atmosphere of a healthy university where it does not have to be related to economic objectives".

IN THIS CONNECTION I would like to draw attention to a recent address published (in May 1962 issue of the *Nature*) by Prof. P. M. S. Blackett in which he has given very practical suggestions for the integration and administration of a post-graduate science department engaged in both active teaching and research. Prof. Blackett has suggested that research in such departments should be organised in a number of almost independent research units dealing with a specific aspect of the subject. He has rightly placed emphasis on not allowing these units to "fall below

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the critical size for self sustaining research progress". These autonomous units should organise themselves into a Department with a Head (may be rotating) for shouldering the post-graduate teaching activity of the Department. He has also suggested a number of novel type of academic relationships between post-graduate and under-graduate wings of a Departments, which deserve our special consideration.

TO IMPROVE THE STANDARD OF research in the Universities, the following points need special attention :

(i) EQUIPMENT AND LIBRARY : Although there has been distinct improvement of these and allied fields with the help of liberal grants from the U. G. C., the position has in fact, become relatively worse when the rapid advance of science on an international scale is taken into account. The effect of this has begun to be felt particularly during the last five years as the grants have remained in the third plan almost at the same level as during the second plan. As was pointed out at a meeting of Scientists and Educationists held in August 1963 to consider the progress in the implementation of the Scientific Policy Resolution of the Parliament, the expenditure on scientific research in India amounts to only 0.32% of the national income, whereas this percentage is about 3% for advanced countries like U.S.A., U.K., and U.S.S.R. and is 0.70% even for China. Taking the case of China as a parallel, the total expenditure in that country has increased from 480 in 1956 to 2,000 million rupees in 1960, whereas the corresponding rise in India has been only to about 400 million rupees in 1960 from 189 million rupees in 1956. This aspect requires immediate attention of our planning authorities and the grants to the Universities must be raised to 5 or even 10 times in the next plan period to enable them to maintain efficiency in teaching and scientific research.

Apart from grants, the question of foreign exchange is of great importance. In view of our extremely difficult position, every possible effort should be made to reduce our reliance on foreign imports to the barest minimum through improvisations (which are generally possible and are even more educative). Even then, there is an absolutely imperative need for increasing this quota to at least 10 times of the present figure, otherwise a substantial portion of the grants to the Science Departments goes to the profiteers in these fields. There is again a very urgent need of the simplification of import procedures so that very long hours which the Professors of Science Departments have to spend in signing such papers could be utilised for more useful academic work.

There is an urgent need of the appointment of administrative assistants in the grade of Lecturers to help the Heads of Departments; this recommendation was

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made by the Chemistry Advisory Committee of the U. G. C. and deserves consideration.

(ii) FELLOWSHIPS : There should be a flexible provision of research fellowships for all students who can attain a particular prescribed level in their University career. This would enable the students to look forward to an academic research career and would be a great incentive to them in their studies.

Post-doctoral research has not been able to progress at all in our Universities so far. Conditions of awards and their tenure have to be made more attractive to attract and retain a limited number of really talented researchers of proved merit and performance. The appointment of some Research Readers and Professors who will have a much lower than normal load of teaching is also a step which should be given serious consideration.

(iii) The provision of Advanced Centres should be spread as widely as possible throughout the country.

IN ADDITION TO CATERING for their own requirements, a wing of these advanced centres should be developed to serve as Service Units for adjoining Universities and even other research organisations. With our limited resources, it is not possible to equip the laboratories of all the Universities to even a minimum desirable standard. The availability of these services (such as I.R., N.M.R., E.S.R., Election Microscopy data) will enable even smaller centres to carry out their programmes of work and give them a final finish in keeping with the international standards.

By : U. N. CHATTERJI

Biology has not yet caught the imagination of students. Is it because the teaching is faulty? Or because the equipment is archaic? An eminent university professor poses all these and many other questions and seeks to answer them.

THE PROBLEMS OF BIOLOGY TEACHING IN INDIA

BIOLOGY is a fascinating subject. It is a scientific discipline which leads its votaries to direct and intimate contact with raw Nature, to observe its various aspects and the changes taking place therein. It sharpens their powers of observation and deduction of logical inferences from observed facts. Man is a unit in the biological cosmos. Therefore the study of biology leads to a better understanding of human nature and of the responsive communion which man has developed in relation to his surrounding environment. Biology is also of great cultural value because the study of biology raises the mental level of the student, tends to satisfy his curiosity and indicates the lines along which progressive ideas should naturally be correlated with the advances in other sciences and humanities. Recently biology has developed added importance with the conquest of space and initiation of interplanetary flights. Biological problems connected with man's mastery over space is

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gradually assuming increasing importance. Space biology in future is surely to find an honoured place in the study of scientific subjects.

IN VIEW OF what has been said above, it is strange and astonishing that biology in this country has not been able to attract suitable types of students. The better types of students or the more promising ones are attracted to the study of physical sciences. No doubt, this is due to greater openings in this country for people who have been trained in the principles of physical sciences and technology. This is an age of technological progress and, therefore, physical and technological disciplines would naturally hold greater promises to people who have been trained in these fields of scientific disciplines. Even then biological progress both in thought and experimental details and in field work is assuming much greater importance than has hitherto been accorded to it because in these days biology has been shown to be connected with technological research programmes in many fields specially in medicine and agriculture. Unexplored fields and richer aspects would certainly be added to the sphere of biology as technology advances not only as limited to the progress of human civilization but also as inter-planetary flights become increasingly successful.

THE REASON WHY BIOLOGY has not caught the imagination of students in general is that biology is presented to them as an assortment of disjointed facts which apparently has no connection with the day-to-day life which they lead both in the class-room and outside. Biological science is never given as a course of study in which all aspects of life and life-processes are stressed, not even the pressing points of social biology. The usual repetition of unrelated facts of the anatomy of frog or stem or root of a flowering plant are doled out to the students without imagination and without correlating them to the actual facts of the student's life. Moreover, it appears that the student is taught not biology but two distinct branches of biological disciplines: one connected with animals and the other with plants, as if these are two distinct and separate entities without any possible connection with each other. The basic principles of biology, as they underlie the life processes, whether they originate in the morphological set-up of animals or plants, are never placed before the students, and the organic and integrated summation of biological thought is altogether absent from the presentation of the subject which the teacher gives in his class.

It is not surprising that the teacher is deficient in the manner and method of teaching biology as an integrated subject. This is because he himself is a product of such a training as has been indicated above although he may have passed the

post-graduate examination in Botany and Zoology, and in addition might have obtained a degree or diploma in teaching. Unless this shortcoming is remedied, and a biology teacher with the adequate experience and background of biological training is ensured, it will be very difficult for biology courses to attract appropriate types of students who would like to seek careers in biology either as a research worker or a teacher at the secondary school level or of the university status. He may even have an ambition of joining some technological institute devoted to biological sciences but his career and training and his academic background does not ensure for him a suitable job in such an organisation.

NOT ONLY THE RAW MATERIALS, as regards the teacher and the taught, are lacking, the class-rooms and laboratories also are ill-equipped. Drawing of diagrams is one of the most important features of biology lecture-room teaching, but in most institutes even the blackboards are such that no worth-while diagram can be drawn thereon. Not only diagrams but even writing on those blackboards is a problem. Even such lecture rooms are ill lighted with no arrangement for projection of lantern slides or projection of films from actual life which will be of great help to biological teaching and make it more interesting and attractive. Even the rooms in which practical exercises are given, i.e., the laboratories, are the most ill-equipped part of the biological set-up in a teaching institution. The laboratories are not only not properly positioned with regard to light and aeration, but they lack the most elementary equipments and chemicals. Microscopes may be fewer in number than necessary or altogether missing, dissecting lenses may not be available, binoculars may be absent; even if such instruments are present, they might be of some archaic make and type. The insufficiency of these equipments frustrates the students in the class for everyone may not have an opportunity of looking at the biological material which the teacher has emphasized in his lecture or which he has collected or which the students have gathered from limited access to fields and gardens.

MOREOVER, BIOLOGY is at present taught as if it was a static subject and has remained standstill for the last several centuries. The salient features in the evolution of biological thought and the studies, which are in progressive states of development, the personalities who have been connected with the various stages of biological advancement, are never mentioned or their contributions to the science are never stressed. The students leave the class-room with the feeling that biology has no history and it is not developing at all because the teacher does not stress the progressive lines of biological thought operating at present. The student does not have any idea that biology is a progressive science, and is almost every day

characterised by discovery of new facts or new interpretation of facts already known or reported.

Even Indian workers or their contributions to biological thought and progress are never mentioned. The students naturally, therefore, develop the idea that biology is a western science developed only by western scientists.

BIOLOGY IS A SCIENCE which is very close to Nature and observation of Nature and field work are of the greatest importance to all biology students. In the teaching of biology, field work specially gives the student an opportunity to come in contact with living biological material in place of dead specimen which is dished out to him in laboratories for purposes of demonstration or dissection. Here the student sees Nature 'red in tooth and claw', can observe the various natural processes actually taking place, and correlate the knowledge obtained in the class-room with first-hand information he gathers therein. It is surprising that most institutions which give biology courses do not have adequate arrangement for taking students out for biological trips and for undertaking field work. This necessarily handicaps the teaching of biology and the students' interest flags.

THE MOST DIFFICULT problem facing the biology teacher is the selection of suitable textbooks. There is a great dearth of Indian textbooks worth the name written by Indian authors and dealing with Indian biological materials. Whatever are available, are mostly mere paraphrases of the existing foreign books. Materials which are stressed therein are also more often than not foreign; imagine a student learning biology with foreign plant names and description of foreign plants. There is need therefore of suitable and acceptable textbooks which should fulfil this great gap in teaching materials. Also, a supply of proper museum specimens should be ensured; prepared slides and projection materials, which should accompany the class-room discussion or laboratory work as well, should be readily available. It is only then that the student would know that what he learns in the class-room or laboratories about roots or nervous system is what actually happens in Nature, and the specimen he dissects out or what has been demonstrated to him, has been picked out from Nature and preserved for his examination. At the outset the student should be handed over a list of plants and animals that would be easily found in the region in which the student resides or comes from or where the institution is located. He should be encouraged to collect himself many of the specimens representing the local flora and fauna. This will give him a basic idea of biological science and also train him in the collection of biological materials. Otherwise the student would possibly memorise unnecessary, and probably wrong, details which

might not possibly be applicable to the specimen he has collected or to the environment to which he has been familiarised.

ANOTHER GENUINE DIFFICULTY in teaching biology courses is being increasingly felt these days. Mathematics, specially statistics, has invaded the field of biological science, and mathematical and statistical methodology is very often used for the interpretation of biological observations. It is therefore important that rudiments of mathematical and statistical interpretation of biological data are included in school-level courses in biology.

The greatest difficulty, I believe, is poor knowledge of English of almost all the students who opt for a biology course or, as a matter of fact, any science course; this drawback does not enable him to learn and appreciate and discover the true meaning of words stated in his textbook. In such cases much unlearning is required before the student can be put on the proper lines to appreciate the contents of a higher course in biological teaching.

Also, not all the teaching should be based on textbook material in the form of lectures. Audio-visual aids and demonstrations should be freely made use of to impress the facts of biology on the student's mental facet, and bring home to him the correlation of the various features and processes that are invariably connected with the subject or form as its integral part.

IT IS NEEDLESS TO MENTION that biology is a science which is based on manual work. To deny facilities for practical work to students is to deny them the opportunity of learning biology itself. In most institutions practical work is not given the importance that it deserves. In several cases it has been observed that the work done by the teacher in practical classes is not considered to be of sufficient importance to equate it with the period devoted to class-room lecture work. It is shocking to learn that there are instances in which two periods of practical work put in by teachers are equated with one period of lecture work; this is naturally to the disadvantage of the teacher. It is, therefore, natural that the teacher should neglect practical work and give greater importance to theory classes. This problem or shortcoming should be remedied without any loss of time. Practical work should be equated with theory work at all levels of teaching.

THE FACT THAT MANY of the indifferent kinds of students flock to biology courses is probably because it is easier to secure admission to the classes. As a result it has been observed that seriousness on the part of students is generally lacking, and because of this non-serious attitude of the students, biology teaching suffers

from many drawbacks. A class-room crowded with non-serious type of students may be looked upon as a potential danger to the discipline within the class-room as well as a contributing factor to the students' indiscipline in general. It is therefore, suggested that some sort of screening should be introduced to select students for biology courses as well.

It should be realised that India is a poor country and parents of almost all the students, who offer biology as a course of study, come from a cross-section of a population which probably can ill-afford to send their children to institutions where biology is taught because of the prohibitive cost that such a course entails. As the general equipment of students for the biology course consists of certain costly items like dissecting sets, pocket lenses, etc., the students could hardly be expected to buy these for themselves. It should, therefore, be obligatory on the part of the institutions, where the students study biology, to supply them with a set of equipment which is deemed necessary for successful pursuit of biological courses.

THE DIFFICULTIES OF STUDENTS AND TEACHERS are also greatly enhanced because of the absence of a suitable library stocked with appropriate and well-chosen biology books and charts. It has been a painful experience to find that many institutions have been allotting an annual grant of Rs. 200/- only for the purchase of both equipment and books in biology. To say the least, this amount of money is most inadequate for the smallest biology department. Therefore, an essential condition for suitable biology teaching is a handsome monetary grant for purchasing equipment for laboratories and biology books for the use of students and teachers alike.

THE SHORTCOMINGS AND DIFFICULTIES, which a teacher faces in teaching or training students in biological subjects, have been enumerated above. It is assumed that with some sort of co-operation between the institutions and the organisations which finance these institutions, the condition could be greatly improved and suitable provision might possibly be made for the successful teaching of biology. The teachers and students would both derive benefit, if such a condition was ensured.

CHEMISTRY IN SCHOOLS

RETROSPECTS AND PROSPECTS

A Frank and objective appraisal of what we teach today

By RAM CHAND PAUL
AND
ASHOK KUMAR

THE PRESENT is the age of science and technology and consequently the prosperity of any country, particularly a developing country like India, is rooted in the advances made in these fields. India has completed eighteen years of her independence and during this period she has made great strides, on her own initiative and efforts and also in collaboration with others, in various fields of science and technology, in an effort to move in line with the scientifically more advanced countries of the world. But we feel concerned that our pace of progress has been too slow to catch up with them. We are still facing serious shortages in agricultural and industrial production as well as in technical personnel for manning our national projects. Because of the critical times our country has been passing through, we should realise the hazards of depending too much on the foreign technical

assistance. Of late, our nation is becoming conscious of the fact that it will be difficult to push the country towards prosperity and self-sufficiency without proper cultivation of the scientific know-how in our country and this can be made possible only through a rigorous planning for science and technical education for our students.

It is a well-known fact that nations always develop through effective programmes of education. In the present times when the foundations of all progress lie largely on scientific education, it becomes necessary to chalk out and develop effective study materials in science subjects for our young students. No doubt, science education is being imparted in our schools and even efforts have been made to expand and improve this training but the extent to which success has been achieved needs comment and critical consideration. Unfortunately, so far we have not made any frank and objective appraisal of the problems of science education in our country and, therefore, in the present article an attempt has been made at an appraisal of the present situation and a few suggestions for future improvement are given.

Post-independence educational efforts :

IT WAS ONLY AFTER ATTAINING FREEDOM that India could effect orientation in the pre-independence Macaulay's system of education and since then, efforts for the rapid expansion of education at all levels of our educational ladder have been going on. One of the immediate results of the three Five-Year Plans is evident in an all-round increase in the number of School, College and University-going students in our country. But our three Plans have resulted mainly in an extensive expansion of educational facilities but the quality of education has not improved much. To be more precise the quality has not been emphasized at any time and it is now rightly feared that under the impact of future expansion of education, its quality may further deteriorate. More expansion of educational programmes will not take the nation to the desired goal, if expansion means merely the multiplying of the existing defects and deficiencies and projecting them on a larger screen and on a bigger scale. If our system of science education had been progressive in nature, these 18 years of our country's independence might have given a new shape to our educational programme. The meagre results produced in various phases of our national reconstruction, are an ample testimony to this shortcoming. Therefore, there can be no two opinions that in India, the quality of education in general and science education in particular have been far from satisfactory.

Mode of keeping abreast of new educational trends :

WITH A VIEW to improving the quality of education in our country, attempt was made to improve the pattern of education by converting some of the High Schools into Higher Secondary Schools, that is, from 10-year schools to 11-year schools and by converting the Two Year Degree Course into a Three-year Degree Course (T.D.C.), and introduction of such classes as Pre-Engineering and Pre-Medical. The course content for these classes has, however, remained the same. What was previously taught in the Two-year Degree Course is now being done in the last two years of the Three-year Degree Course. Another strange notion that seems to prevail is that we can keep pace with the expanding fronts of scientific education by making General Science, Biology, Physics and Chemistry text books thicker and thicker with the inclusion of more and more of the findings and applications of science. No evaluation of the instructional materials taught to our school students has been carried out to see whether they keep up the spirit of learning and the country's needs. Till today nothing has been done to prune the redundant portions of the school science curricula and to substitute in their place more useful materials in spite of a loud talk from many quarters to do so.

Need for changing existing science curricula :

WITH THE EXPLOSION of knowledge that has taken place during the last two decades our nation is faced with educational problems that require a radically different approach. It may be mentioned that our science curricula for school and undergraduate levels have continued almost unchanged ever since India attained independence. Most of the changes have been of a minor nature and no change of a fundamental significance has so far been introduced. However, modern developments at curriculum improvement have started influencing the curricula for M.Sc. courses in some of our Universities. But the M.Sc. students invariably having been fed on the traditional courses at their school and undergraduate levels, find it difficult to grasp the spirit of the improved M.Sc. curricula. As a result of this we are not able to achieve the aim with which the changes in curricula are planned. In fact, these M.Sc. students begin to feel that their courses are completely unrelated to what they have been taught earlier. This feeling is true because there is no continuous link in what they learn from the school stage onwards and their approach to science becomes superficial and unrealistic. It is, therefore, of utmost importance that modern developments should begin to exercise a substantial influence on our school science curricula.

Although conventionally and for the sake of convenience, one makes distinction between Primary, Secondary and University education, the entire process of learning is a continuous one and each stage is dependent upon the one preceding it. Any defective learning and teaching at the primary stage would present difficulties to the teacher as well as to the taught at the secondary stage. Similarly, deficiencies in the secondary education would make their defects felt at the college and the university level. The gap between the school and undergraduate syllabi (which have remained unchanged all these years) and the post-graduate courses (which have been gradually changing) needs to be bridged. The question now is what should be done first to narrow this gap and then to bridge it completely. It is an experimented fact that for the teaching of any science, curriculum improvement is fundamental to any organised effort at improving the quality of science education in any country.

High School Science curricula to be function-oriented :

THE EDUCATION UPTO the secondary school forms the background for college and the university education in spite of the fact that many of these outgoing school students may discontinue their studies after the school stage. It is also likely that some of the students would go in for vocational courses instead of joining the colleges. The knowledge imparted in science subjects at the secondary school should be sufficient to enable them to choose their future career. The syllabus has to be brought out in such a way that it would indicate to the student the scope of each of the sciences and yet enable him to choose vocation of his choice. Since only a small percentage of our student population may go in for higher education in the colleges and the universities, in the interest of the higher education alone, the general education in our schools should not suffer. The curricula should be so framed that some of the students may leave off their education after 7th, 10th or 12th year of the school/college education.

Importance Of a syllabus co-ordination committee :

THE TEACHING OF SCIENCES today, in every region of our country, is controlled by a large number of committees which usually do not have much co-ordination among themselves. The School-Board is probably independent of the committee which frames syllabi for the college level and also independent of the committee which frames syllabi for the university stage and these committees prepare courses independently of each other. This results in a lot

of repetition of the subject material at different levels and thus wastage of time of the student and the teacher. It would be better to entrust the preparation of the syllabi at all levels to one committee consisting of teachers of that subject at all levels who may prepare a unified syllabus and then allocate portions for different classes and thus avoid all unnecessary repetition and overlapping; at the same time, keeping in view the different stages at which the student may discontinue his studies in favour of choosing a vocation. This aspect is really very important taking into consideration the present economic standards of the people of our country.

Syllabus drafting :

BY ITS VERY NATURE, a syllabus cannot give the precise idea of what is intended to be done. The mere mention of broad topics does not indicate the extent or depth to which the teacher has to go or the manner in which it is to be related to the other topics. Our syllabi are generally drafted in this fashion. Thus not only the syllabus is to be laid down but precise explanations and detailed references to the extent to which the topics are to be covered are very necessary. Thus there have to be prepared what may be called 'synopses' for the topics included in the syllabus. The draft of a particular syllabus has also to take into account the period assigned for its proper execution.

Period of schooling unnecessarily controversial problem :

AN 11-YEAR HIGHER SECONDARY EDUCATION pattern was suggested a long time ago but most of the states of our country are still following the old 10-year Matriculation or S.S.L.C. pattern, providing for the 11th class as Pre-University course. According to the present thinking of the Education Commission of the Government of India, the first degree course in Science should be of 3 years' duration and it should follow at least 12 years of schooling. Class X is to be the terminal point followed by two more years of preparation before the start of the regular degree course. The Commission also seems to be of the view that ultimately classes XI and XII should form a part of the school education. For no understandable reason the decision on the period of schooling has been made a debatable question. What matters is not so much the duration or the pattern of schooling but the knowledge level to be attained at the end of the school course or the beginning of the University education. There could be flexibility in the assignment of different classes to schools and colleges depending upon the facilities available. In the Panjab, Classes IX and X (High Classes) are taught in the schools. Class

XI is held in the Higher Secondary schools but where it is held in colleges, it is called Pre-University Class. However, the course content in science subjects for the Higher Secondary and the Pre-University classes is the same. Class XII which comprises three equivalent classes, that is, Pre-Engineering, Pre-Medical and First Year of the Three-Year Degree course, is taught in the colleges alone. Keeping in view these stages, it is appropriate that the problems relating to the education in science subjects in our country at all these levels are discussed now. But in this article we have confined ourselves to the subject of Chemistry only and have given a few suggestions for future improvement in its teaching.

Introduction of chemistry at different levels :

FOR A GRADUAL BUILD-UP of the subject of Chemistry its study may be divided into various sections by spreading it properly throughout the School Chemistry curriculum. In the Junior Classes, it may form a part of the Nature Study (Air, Water, etc.), later on as a part of General Science Course in the Junior High/Middle Schools. There is a lot of confusion among our teachers of science education whether General Science should or should not be taught after VII or VIII class and the issue still remains undecided. It is surprising why even such ordinary things do not find quick solution at the hands of our educational experts! The simplest and the most practical way would be to introduce a rigorous General Science course for students upto class X and diversification of courses should start only after that stage of schooling.

UPTO CLASS XII there should be a General Chemistry course. Teaching of Chemistry is done at present under three different headings in the class XII, that is, Physical, Organic and Inorganic. This is, however, not correct. To attempt to teach different branches of Chemistry separately is to give the student the impression that each branch of Chemistry is an end in itself. It cuts at the root of correlation and co-ordination of different branches of the subject and prevents the student from acquiring a unified view of the subject. Besides it results in unnecessary repetition leading to wastage of time and energy of the teacher and the taught. The approach to the subject should be unified particularly so at the elementary stage of the education of the student.

Existing chemistry syllabi for classes IX to XII :

IN THE APPENDIX ATTACHED are presented the present syllabi in Chemistry for IX, X, XI and XII classes in the Panjab to enable fellow teachers of Chemistry

to develop their own reactions to the traditional type of education our school students are at present receiving in Chemistry. The syllabi in Chemistry in the other states of the country have also been looked into. More or less, the instructional materials are the same with the following aspects dominating them.

Emphasis on fact-centred chemistry :

THE EXISTING SYLLABI are totally based on the descriptive chemistry of the good old days. There is a lot of emphasis on memorisation of formulae, processes and facts. It is really sad that with such a course work we are deliberately curbing the natural development of the students' faculties of observation and interpretation of scientific phenomena. Facts in themselves are very easy to learn for they do not involve any thinking and human mind has certainly a lot of capacity for retaining them and committing them to memory. But there is a limit even to memorisation of facts, for the scientific knowledge is expanding at a tremendous rate. Modern chemistry can be mastered only by thoroughly learning the few basic concepts and then applying them as tools to interpret and predict new chemical facts. In the interest of the subject, therefore, our teaching must change from fact-centred to principle-centred one.

Alternative to teaching of descriptive chemistry :

AT THE ELEMENTARY STAGES OF science education, there is no sense in wasting time on the teaching of historical material of the subject. If need be, History of Chemistry may be taught as a separate subject in the advanced stages of the students' education. Since the main object of teaching such a material is to familiarize the student with the development of scientific thought this will be best done by including small biographical sketches of the renowned chemists in the language texts and not in the books of Chemistry.

Unnecessary repetition and inclusion of certain topics :

AS HAS ALREADY BEEN SAID, because of lack of proper co-ordination among committees for drafting syllabi for different levels most of the items are unnecessarily repeated. Preparation, properties and uses of gases like oxygen, hydrogen, sulphur dioxide, carbon dioxide are taught in classes IX and X and again in class XI with the only difference that in the former two classes the chemical reactions representing their properties are written in words. This itself is wrong for the very

conception of a chemical reaction is not conveyed properly by writing the chemical equation in words. The tendency of representing chemical reactions in words and then translating them should be discouraged. Allotropy of carbon, sulphur and phosphorus and account of safety matches are other similar examples.

A glance at the appended syllabus will also indicate that most of the topics included in the present syllabi for classes IX and X, with slight modifications here and there, should form a part of the General Science Course. The suggestion then automatically fits into our view that upto class X Basic Chemistry should be taught as a part of the General Science. This point of view is being elaborated in a separate article.

Obsolete preparative methods :

THE BULK OF THE descriptive material taught comprises many obsolete methods of preparation of number of substances. In all preparative reactions, the most important is the relative yield which is never brought home to the student. He is required to commit to memory all those methods, practical or obsolete, and strangely enough, many times he is penalized for omitting a particular method in answer to a question set in the examination ! A reference to the "Text-Book Errors Column" in the 'Journal of Chemical Education', will reveal a large number of such discrepancies about preparative reactions and other topics which form the salient feature of most of our Chemistry books based on the existing syllabi.

Physical and Chemical Changes :

IN MOST OF THE BOOKS on Chemistry for our schools, the subject matter is started with the definition of a Physical Change and a Chemical Change. Solution formation is taken to be a physical change which is far from true. Most of the ions in solution are solvated by the solvent molecules. NaCl dissolves in water and results in the formation of $\text{Na}(\text{H}_2\text{O})_n^+$ ions. Addition of water to anhydrous copper sulphate gives the blue copper sulphate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, in which water molecules are quite firmly co-ordinated. If the energetics of solution formation are taken into account it may be pointed out that in solution formation, in some cases, energy changes involved may be large enough to exclude these from the purview of physical changes. Since this section does not serve any useful purpose and is misleading, it may be dropped or at least solution formation excluded from this discussion.

Daltonian Concept still the theme of our school and college chemistry :

IN SPITE OF THE FACT that some of the older concepts have become outdated, they are still being stressed in the earlier stages of chemistry teaching. For example, in our schools and also in our colleges, the teaching of chemistry is centred round Dalton's Atomic Theory. The result of such an approach is that even our graduates in chemistry say and feel that the outmost orbit can not have more than eight electrons. That the electrons move in circles round the nucleus and that they can be located, is the picture of the atom that these students develop at their school and college levels. It is very difficult at later stages of their education to change such concepts for newer ones.

No reference to the Periodic Table :

THAT THE PERIODIC TABLE is little known in our Chemistry curricula upto class XII, speaks for the actual state of affairs in our teaching of Inorganic Chemistry. The Periodic Table is introduced at the B.Sc. level but there also it forms a chapter of the book without emphasizing its role in the periodicity of the physico-chemical properties of the elements. Therefore, the student is naturally more familiar with the history of the development of the Periodic Table than with the understanding of its role as a basic concept for the systematisation of Inorganic Chemistry.

In the present graduate level, the old form of the Periodic Table, in which each group is divided into sub-groups A and B, is being taught. It has been recognised everywhere that this is not the best way of arranging the elements. There is practically nothing in common between the Alkali Metals and the Noble Metals which form sub-groups IA and IB and similarly between the halogens and manganese, etc. which form sub-groups VIIB and VIIA respectively. The Long Form of the Periodic Table is much better since it completely follows the filling up of the electronic shells. In this the sub-groups IA and IIA along with hydrogen and helium represent the elements where s orbitals are being filled. Groups IIIB, IVB, VB, VIB, VIIB and O form another group of elements where p orbitals are being filled. Sub-groups IIIA, IVA, VA, VIA, VIIA, VIII, IB and IIB form the third group of elements where d orbitals are filled and these are together called the Transition Elements. These elements have more in common with each other than with the earlier corresponding two sub-groups. Lastly we have two groups of 14 elements each where the f orbitals are being filled; these are the lanthanides and the

actinides. Thus this arrangement completely follows the atomic structure and should be adopted in the teaching of Inorganic Chemistry at all levels.

Concept of 'Mole' in Chemistry :

The applications of Avogadro's law are no doubt discussed in the existing books by making reference to the classical examples, but no attention is paid to Avogadro's Number and the concept of 'Mole' is never taught. Almost all the recent books on chemistry in the outside world are based on the 'Mole' concept which is used in solving numerical problems.

Old concept of the chemical bond still emphasized :

One of the unifying concepts of the High School Chemistry is that of the nature of the bond that binds atoms together into compounds of various kinds. This bond was for a long time merely indicated by a line or lines between the symbols of the chemical elements but the nature of the force and the binding mechanism were completely obscure. Right upto our degree courses the students are ignorant of the real significance of a chemical bond, and since more than this is not required by the syllabus in vogue, nothing is taught about the movement of electrons round the nucleus and their role in providing the chemical bonds between atoms.

'Aliphatic' and 'Aromatic' need not be taught separately :

IN THE ORGANIC CHEMISTRY portion a lot of saving of time can be effected; besides helping the student acquire a more sound basis of the subject if the 'aliphatic' and 'aromatic' portions are dealt with together. All that is needed for doing so is to explain the (catenation) property of carbon atoms to form chains both 'open' and 'closed'. At present, the student is first told of open chain organic compounds and only after six or seven months he is taught that carbon atoms can also form ring structures.

"Chem Study" and the Indian Schools

IN THE UNITED STATES of America, during the past few years, considerable thought and effort have been directed at developing new approaches to the teaching of chemistry. Two independent groups of educators were organised to develop teaching programmes in General Chemistry at the High School level. One group became known as the 'Chemical Bond Approach project (CBA) and the other was called the Chemical Education Material Study (Chem. Study).

"The Chem Study course approaches the study of Chemistry as An Experimental Science. It is a laboratory-centred course which features experiments which will permit the student to make his own discoveries of regularities and principles which unify chemistry and make it easier to understand. It emphasizes the making of careful observations and quantitative measurements under controlled experimental conditions. It stresses the preparation of well organised tables for recording data and the results of calculations so that the student can more readily make deductions and recognise regularities which exist. It uses challenging discussion questions which will help the student to apply the principles observed in the experiments to new situations."

EFFORTS ON THESE LINES have also been made in the U.S.S.R., U.K., Japan and in many other countries of the world. The pattern adopted is more or less as cited above, and, therefore, it is high time that in India too, similar changes should make their impression on the teaching of chemistry.

There will not be much utility of appointing committees for drafting syllabi for various levels. Even if this is done, the quality of the drafted curricula will more or less conform to what is actually contained in the Chem Study or similar other books, for this is the material which should be taught to young students. Therefore, a more practical approach will be to modify these books to our conditions and introduce them for the time being to make a beginning in the new experiment.

The National Council of Educational Research and Training, New Delhi, has done good work by bringing out the Indian Reprint of Chem Study which is now available at a very cheap price. The next step in this direction should be to translate these books into Indian language to be utilised by a wide range of students all over the country. It is very important, however, that the translation work should be done under the close scrutiny of teachers of Chemistry.

Teaching Function of the Science Laboratory

CHEMISTRY IS UNDOUBTEDLY an experimental science. The discovery of the chemically reactive behaviour of the so-called 'inert gases' by experimental chemists bears a good testimony to the fact that Chemistry thrives best in an experimental atmosphere. Theoretical advances of whatever magnitude ultimately find support in experiments conducted in the laboratories.

With a change suggested for the present in favour of Chem Study the importance of the laboratory work stands well marked out. In these courses, students

gather evidence and try to discover its significance before the principles are actually discussed in the class-room. Since these courses are laboratory centred, it is imperative that the teaching function of the chemistry laboratory is properly emphasized. It is very discouraging that the laboratory work in our schools is not carried out with the zeal expected for such a work. Somehow or other many wrong notions are prevailing regarding practical work and till these are removed, experiments at curriculum improvement may not meet with any significant success. It is not out of place to make an inward inspection of the pattern in which the laboratory programmes are carried out in our schools and colleges.

Mode of execution :

IN OUR SCHOOLS, science practical work is treated as a non-serious occupation of the students. From discussions with many of the school science teachers (from different parts of the Panjab) who have been receiving in-service training in Chemistry in the Panjab University, it is revealed that the science practicals do not form a regular feature of the school time-table. Such a work is done either in the vacation or after the school hours and often near the annual examination. Fortunately, however, in our colleges and universities, no such discrepancy exists. But we are still following the classical way of laboratory work. The emphasis is only on routine and prescription type experiments. The teacher describes a particular experiment and then the student goes into the laboratory to perform it. The laboratory course should be organised in a way as to aid the student in the study of the interaction of conceptual schemes with observation and experiment ensuring thereby that the student not only collects data in the laboratory but he also applies ideas to his data.

Supervision :

THE SUPERVISION OF the practical work in our schools, colleges and universities is generally entrusted to the comparatively less experienced members of the teaching staff. Lack of interest in the laboratory attention on the part of the senior teachers is the single most important factor which undermines the spirit of the laboratory science. The only part that such teachers play in the laboratory programme is that of giving instructions for about half an hour or so on the bare routine performance of the experiment and then they almost skilfully slip away for some other work wherein they are probably more interested.

Working in batches :

FOR OBVIOUS LACK OF SIMPLE EQUIPMENT and materials needed in the chemistry experiments it is not possible to give an individual batch space for carrying on experiments in the laboratory. However, it is essential that all students should take part in the practical work as participants and not as spectators. But with the training that our students have, the two in a batch generally assign themselves to different portions of experiments which they are asked to perform. Thus each one of them gets familiar with one part only and neither is familiar with the experiment as a whole. However, there are many experiments where a group of students may have to work together. Such experiments are either those which involve some equipment which is not available in plenty or those where the student is to be trained to the system of team work in science.

Maintaining and checking of record :

Dependent on the manner in which the practical work is carried on it is but natural that the student develops neither the habit of maintaining records nor does he get them checked regularly. Barring a few exceptions, which are always there, the teacher simply signs the note-books, generally in token of his having marked the student present in the attendance register.

Demonstration experiments :

Working on their own, the students will do far fewer experiments in the time available; and to make up for that the teacher should perform demonstration experiments. The effort of teaching by demonstrations has a deep influence on the retaining capacity of the student. Unfortunately, the practice of demonstration experiments seems to be dying out gradually in our schools and colleges.

Ill-Equipped and unplanned laboratories :

ALL SCIENCE LABORATORIES cannot be alike. Depending upon the nature of the experiments to be performed and the subject, the planning of the laboratory has to be different. For reasons too well known and because of lack of proper attention on the part of authorities of all our schools, one laboratory caters to the execution of General Science, Physics, Chemistry, Biology, etc. The position of good equipment and material is even more serious. We cannot expect our students to do what is best in circumstances which are adverse. Therefore, in each region of the country there should be centres for the production of laboratory equipment, so that the

apparatus is more readily available for purchase, repair and replacement. The situation in respect of chemicals is even worse. Very few firms are manufacturing quality chemicals in India and most of such chemicals are at present imported. Production of laboratory apparatus and chemicals in our country will definitely solve many problems of the science education in our institutions.

Instructional materials :

There is undue emphasis on conventional qualitative analysis. With the addition of every year to the student's education, he encounters one or two new radicals in the analysis of the mixtures. Even after practising so hard at qualitative analysis, from the school to the post-graduate level, he remains still a novice analyst. It would be better to decrease this load on the student by introducing simple experiments as mentioned in Chem Study.

It is also very strange that the use of chemical balance is excluded from the practical work of the school students.

Role of films in the teaching of chemistry

INSTRUCTION IN CHEMISTRY as also in other sciences involves a certain amount of demonstration work and some of this material can be presented satisfactorily by films projected in the class-rooms. While such filmed courses cannot replace ordinary class-room instructions, they act as catalysts for the modernisation of science teaching. Where the facilities permit, the schools and colleges should consider providing such equipment as an aid to the teacher, thus allowing him more time for laboratory preparations and for independent work with the students. For the present, however, it is suggested that all Chem Study films should be dubbed in Indian languages so that they can be better appreciated and understood by our school students.

The Ministries of Education in our country must establish centres for the production of science films. These centres may produce both new films and adaptations of those obtained elsewhere. Some of these films could be directed toward teacher education. Some could supplement the laboratory work by showing experiments otherwise unavailable. Some could provide demonstrations using equipment, most institutions cannot obtain and some could show the availability of science careers in our country. An important average of National Films Production Programme will be that local scientists and teachers can be shown on the films working in the local laboratories. This will stimulate scientific interest in the

culture of the country where this aspect, though very vital, is totally absent in our pattern of science education.

Text-Books :

IT IS AGREED that much greater importance is to be attached to the actual writing of the relevant text-books and to the preparation of teachers to teach the same. The text-books in chemistry have to be written by those who are acquainted with modern trends in chemistry and its applications. It may do our nation more harm than good if the introduction of the right type of study materials is deferred simply because books have not been authored by our own people. A large number of General Chemistry Text-Books printed as International Student Editions or Indian Reprints or Eastern Economy Editions or Books for Asian Students are now easily available at very reasonable prices. Let these books be introduced and the new experiment of orientation of chemistry curricula in Indian Schools be undertaken without losing time till some books prepared by Indian authors are available. This should constitute the first phase of the change. Based on the practical experience of this change and the continuing modern developments in science, a re-evaluation of the system could be made. During this time we are likely to evolve an altogether indigenous pattern of education in chemistry and afterwards we may even get better books by our own people.

Examinations :

UNLESS THE EXAMINATION SYSTEM specifically allows for flexibility, it may, in fact, become a powerful force against change and thus seriously hamper efforts to improve teaching. New methods intended to introduce more modern concepts into a course are particularly likely to be hindered by the external examination in which the examiners have not participated in the actual preparation and the teaching of a course in its improved form. This single factor may do more to prevent creative experiments with improved teaching than any lack of funds. Examinations should act as teaching tools and as incentives towards improvement and should not become an end in themselves as is the case at present in India.

Teachers :

AS FAR AS THE TEACHING of teachers is concerned, it may not be forgotten that the process of learning has no finality as such and it may never be thought of as finished at any stage. The process of learning is continuous and, therefore, the problem of teachers has to be tackled on two fronts :

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- (i) to acquaint them with what we expect them to teach;
- (ii) to provide for them the adequate means to continue to learn.

It is not possible to think that the syllabus in any science subject at any time would be the last word on the subject. The continuous growth of science and its applications will demand continuous changes in curricula necessitating a continuous improvement in the professional level of teachers.

Conclusion :

THE NEED FOR CHANGES in the system of science education from the school to the highest level is a development in nearly all the advanced countries of the world. India too must march towards the realisation of such goals without losing any more time. We must spare our future generation of students a painful compulsion to rethink everything that they have learnt earlier. Even the paucity of resources does not justify teaching of science which is out of date. Let us not simply go on philosophizing the role of science as a prime level for socio-economic development of our country. A stage has now come when we must teach and learn what is modern and not dissipate ourselves on materials which are not in keeping with the recent trends in science. Herein alone will lie the development of sciences in India and the sooner we become alive to this reality the better it will be for our nation.

ROMANCE OF TEACHING MATHEMATICS

By

S. P. KAUSHIK

MATHEMATICS because of its nature and structure is peculiarly fitted for high school instruction. Especially the higher mathematics, even if presented only in its elements, combines within itself all those qualities which are demanded of a secondary subject. It engages, it fructifies, it quickens, compels attention, is as circumspect as inventive, induces courage and self confidence, as well as modesty and submission to truth. It yields the essence and kernel of all things, is brief in form and overflows with its wealth of content. It discloses the depth and breadth of the law and spiritual element behind the surface of phenomena; it impels from point to point and carries within itself the incentive towards progress; it stimulates the artistic perception, good taste in judgement and execution, as well as the scientific comprehension of things. Mathematics, therefore, above all other subjects makes the student full of lust after knowledge, fills him, as it were, with a longing to fathom the cause of things and to employ his own powers independently; it collects his mental forces and concentrates them on a single point, and thus awakens the spirit of individual inquiry, self confidence and the joy of doing; it fascinates because of the view-points, which it offers and creates certainty and assurance, owing to the unusual validity of its methods. Thus both what he receives and what he himself contributes towards the proper conception and solution of a problem, combine to mature the student and make him 'skilful' to lead him away from the

surface of things and to exercise him in the perception of their essence. A student thus prepared thirsts after knowledge and is ready for the university and its sciences. "It appears, that mathematics, specially the higher one, is the best guide to philosophy and to the philosophic conception of the world," says Pierpont. Samuel Coleridge remarks "We are often surprised that mathematics, the quintessence of truth should have found admirers so few, and so languid. Frequent considerations and minute scrutiny have at length unravelled the cause, viz., Though Reason is feasted, Imagination is being starved : whilst Reason is luxuriating in its proper Paradise, Imagination is wearily travelling on a dreary desert".

Mathematics in India is not very popular, though it is an excellent preparation for other sciences. They read it with a sigh, a groan, a travail. They call it dry as dust. They have mathematics with tears, as Grammar with tears.

But it is a numerical science, and is not meant for a few special minds. But teach it well and carefully too, for children learn early. Let there be no innervation of mind or the incurable superfluity. It is correct to say that 'teach the four ground rules well and later on they shall reappear in the motion of the universe'. Do not put sensation or glitter in your teaching, but apply reasoned truth. Let books be of delightful style neatly trimmed and contact books. Also teaching is to be a part of general culture, which would help in the comprehension of the development of civilization and the ability to participate in the further tasks of civilization.

Stimulate the inventive faculty, strengthen it, awaken interest, develop mental powers, so that pupils may exercise their judgement; draw correct inferences, teach them the habit of concise statements for brevity is the soul of wit, have rigour and exactness; clear their difficulties, associate the various branches, pure and applied, connect it with the knowledge of nature and with experience to enter into the circle of thought. Give simple proofs and do not make a problematic paralysis; develop power to use algebraic processes as a means of finding results in practical problems. Give not merely illustrations made obvious to the senses, not merely to feel but to think. Let there be no superfluity or lack of scientific methods. Cultivate space intuition, to develop the power to rephrase in clear language, thoughts recognized as correct, to have ethical and aesthetic effects. Try to supply a method of reasoning applicable to other subjects.

Aim at a deep penetration and complete command of abstract mathematical theory, together with a clear insight into the structure of the system for the new uses of mathematics require less manifestation of formulas and equations, but more of these structures and systems.

I admit we have to be creative teachers whose teaching genius stirs the intellectual qualities of the students, awakens their latent potentialities and opens the channels of investigation and study. Buildings are essential; materials and facilities are of great value. Modern teaching appliances are helpful, but nothing can surpass the stimulating influence of a devoted and enthusiastic teacher. We have to be men of character, ability and personality, if we have to imbibe these qualities in our students. We have to have knowledge, love and farsightedness. We reap no more than we sow, and if we really want to provide the class-rooms with qualified and enthusiastic teachers, it is our responsibility to provide the prospective teachers with the kind of teaching that stirs their imagination and increases the respect of teaching profession.

Start with sense objects and bring about gradually transition to abstract formulation. Correct thinking based on true premises secures mastery over the outer world. So have creative and rigorous investigation of the problem you come across or tackle; lay stress on the key idea, which once understood makes the rest purely routine. Build or develop 'Intuition' which plays a great role. Do creative mathematics. Develop something new. Explore new paths. Have literature to inspire you, for libraries are the laboratories of thought. 'Absorb, Explore and learn', suggested Prof. V. V. Narlikar.

We need in our pupils the power of comprehension, increasing development of imagination, logical power, and ability of abstraction, and above all a touch of humour and smile which is not only possible with perfect propriety but very helpful. So make the teaching of mathematics interesting. Show them its interesting applications to other subjects but do not swing the pendulum to the other extreme. Give more effective assistance in clearing the elements of the difficulties that the pupils have. Give occasionally quotations and anecdotes from the lives of scientists and mathematicians, and create interest in your teaching. Do the following interest you?

1. Babbage was one of the founder of the Cambridge Analytical Society, whose purpose, he stated, was to advocate the principles of pure d-ism, as opposed to the dot-age of the university.

2. Euler gave an algebraic demonstration of the existence of God saying in a tone of perfect conviction,

$$\frac{a+b^x}{x} = x, \text{ so God exists.}$$

3. Fermat died with the belief that $2^{2^r} + 1 = a$ prime number. Euler showed that

$$2^{2^5} + 1 = 4294967297 = 6700417 \times 641 \text{ is not prime.}$$

4. Aldous Huxley, an atheist, at his death bed said,

Oh! X^X save me.

5. Tait dubbed Maxwell ($\frac{dp}{dt}$) for according to thermodynamics $\frac{dp}{dt} = J.C.M.$,

where C denotes carnot's function and the initials of J. C. Maxwell's name.

On the other hand, Maxwell denoted Thomson by T and Tait by T', so that it became customary to quote Thomson & Tait's Treatise on Natural Philosophy as T & T'.

श्यामपट्ट के सामने से

उच्च माध्यमिक विद्यालयों में विज्ञान का अध्ययन और समस्याएँ

विज्ञान वर्तमान जीवन का एक मुख्य अंग बन चुका है और इसको शिक्षा के पाठ्यक्रम में एक महत्वपूर्ण स्थान प्राप्त हो गया है। विज्ञान का अध्ययन आर्थिक दृष्टिकोण से ही नहीं बल्कि मानव जीवन को समाज में अधिक सफल बनाने व उसे इस स्वतंत्र और स्वाभिमान व्यक्तित्व प्रदान करने के लिए, आवश्यक समझा जा रहा है। इसी महत्व और उपयोगिता के कारण, आज लगभग सभी परिवार यथाशक्ति अपने बच्चों को उच्च व उच्चतर कक्षाओं में विज्ञान विषय पढ़ाने का परामर्श देते हैं और यही कारण है कि आज इस विषय के अध्ययन करने वाले विद्यार्थियों की संख्या द्रुतगति से बढ़ती जा रही है। इसके साथ ही विज्ञान का क्षेत्र आर्थिक, सामाजिक और सांस्कृतिक दृष्टिकोण से इतना व्यापक हो गया है कि उसका सम्बन्ध आज के पाठ्यक्रम और पाठन-विधियों से असंतुलित हो चुका है। उपरोक्त कारणों के फलस्वरूप आज सभी कक्षाओं में विज्ञान का सुचारु रूप से अध्यापन कराने में अनेक प्रकार की समस्याएँ व कठिनाइयाँ उत्पन्न हो गई हैं।

आज विज्ञान की प्रत्येक कक्षा में औसतन ४० विद्यार्थी होते हैं। विज्ञान जैसा विषय पढ़ने

में एक कक्षा में इतनी संख्या के होने के कारण छात्र ठोक ढंग से इसका अध्ययन नहीं कर पाते और इसी कारण विषय के मूल उद्देश्यों की प्राप्ति नहीं हो पा रही है। कक्षा में जो प्रयोग किये जाते हैं उसे इतना बड़ा समूह अच्छी प्रकार निरीक्षण भी नहीं कर सकता और फलस्वरूप प्रयोग में होने वाली मुख्य क्रियाओं को वह समझ नहीं पाता। गहराई से निरीक्षण करने की क्षमता और उसके आधार पर विश्लेषण करने और निष्कर्ष पर पहुँचने की योग्यता सीमित रह जाती है। अतएव विज्ञान की कक्षा में २५ विद्यार्थियों की संख्या अधिकतम रहनी चाहिये ताकि प्रत्येक बालक-बालिका कार्य करने का पूर्ण अवसर व अध्यापक का संरक्षण प्राप्त कर सके।

विज्ञान के महत्व और विशेष उपयोगिता के कारण आज सभी स्तर व क्षमता तथा तीव्र, औसत और मंद बुद्धि वाले बालक इसका अध्ययन करते हैं। यदि माता पिता को कभी भूल से उचित सलाह देते हुए कह दिया जाये कि आपका बालक विज्ञान के विषयों के अध्ययन की अपेक्षा वाणिज्य या कला के विषयों का अध्ययन करे तो ज्यादा सफलता प्राप्त कर सकेगा तो वे इस पर विचार करने की अपेक्षा इस

प्रकार के सुभावों को बुरा मानते हुए यहाँ तक कह देते हैं कि उनके बालकों की अध्यापक उन्नति नहीं चाहते, हालांकि कुछ केंद्रों पर बालक की क्षमता की जाँच कर उन्हें इस विषय को लेने का परामर्श दिया जाने लगा है। परन्तु अब भी अधिकांश जगहों पर और उन केंद्रों पर भी ऐसे बालक जो इस विषय के पढ़ने की क्षमता नहीं रखते इसका अध्ययन करने हेतु प्रवेश पा रहे हैं जिससे उन बालकों का भविष्य अंधकारमय बन जाता है। इसके लिये आवश्यक है कि प्रत्येक विद्यालय में जहाँ यह विषय पढ़ाया जाता है बालकों को आठवीं कक्षा के बाद विषयों का चुनाव करने में परामर्श देने हेतु उचित व्यवस्था होनी चाहिये। प्रारम्भ में अध्यापकों को इसका प्रशिक्षण देकर उन्हें यह जिम्मेवारी दी जा सकती है। इसके अतिरिक्त प्रत्येक बालक को प्रथम व द्वितीय मासिक टेस्ट के पश्चात् भी अपने विषय को बदलने का पुनः परामर्श देकर उनके जीवन को असफल बनाने से रोका जा सकता है। आज ग्राम्य क्षेत्र में ऐसे तीव्र बुद्धि वाले बालक भी हैं जो गरीबी के कारण दूर स्कूलों में विज्ञान विषय का अध्ययन करने हेतु नहीं जा पाते हैं। इससे प्रतिभाशाली विद्यार्थी अवसर प्राप्त नहीं होने पर गुदड़ी के लाल बने रह जाते हैं व उनकी विशेषताएँ ग्राम्य क्षेत्र में सीमित रह जाती हैं। इससे राष्ट्र को उनकी विशेष योग्यताओं के पूर्ण उपयोग से वंचित रहना पड़ता है। यदि माध्यमिक शालाओं में ऐसे बालक-बालिकाओं का चयन कर उन्हें छात्रवृत्ति व अन्य आर्थिक सहायता देकर विज्ञान का अध्ययन कराया जाय तो देश को अच्छे व कुशल वैज्ञानिक, डाक्टर, इंजिनियर आदि मिल सकेंगे। यदि विज्ञान के विकास के

इतिहास को देखा जाय तो यह दीख पड़ेगा कि विज्ञान की उन्नति गरीब विद्यार्थियों के श्रम और लगन से ही हुई है अतः हमें भी उन सभी तीव्र बुद्धि वाले बालक-बालिकाओं को ढूँढ़ कर आगे लाना चाहिये।

प्रयोगशाला में ४० विद्यार्थियों के प्रयोग के लिये उचित स्थान व सामग्री उपलब्ध नहीं होने के कारण प्रत्येक बालक को स्वतंत्र रूप में कार्य करने की सुविधा नहीं मिलती, इसलिये उनमें आत्म-विश्वास व वैज्ञानिक दृष्टिकोण उत्पन्न नहीं हो पाता है। यदि प्रत्येक विद्यार्थी को अलग-अलग प्रयोग की सुविधा दी जाय तो उसके लिये पर्याप्त सामग्री, स्थान व अधिक अध्यापकों की आवश्यकता होगी जो शायद वर्तमान परिस्थितियों में सभी जगहों पर सुलभ करना आर्थिक दृष्टिकोण से संभव नहीं हो सकेगा। अतएव इस कठिनाई को दूर करने के लिये, कम से कम, स्कूलों में ग्रीष्म, दीपावली, बड़े दिनों के अवकाश व अन्य अवकाश में प्रयोग करने की सुविधा दिलाने की तरफ विशेष कदम उठाया जा सकता है। इसके लिये अध्यापक को छुट्टियों में कार्य करने पर कुछ विशेष लाभ पहुँचाने की तरफ निर्णय लिया जा सकता है। इससे अध्यापक छुट्टियों में कार्य करने के लिये अवश्य आगे आयेंगे।

उच्च कक्षाओं के पाठ्यक्रम में प्रत्येक बालक को १० विषयों का स्वतंत्र रूप से अध्ययन करना पड़ता है अतः एक विद्यालय के समय-चक्र में विज्ञान विषय के अध्ययन व प्रयोग करने हेतु पर्याप्त समय नहीं मिलता। यदि अवकाश के दिनों में प्रयोग की विशेष सुविधायें दी जायें तो बालकों को इस विषय के अध्ययन व प्रयोग करने के लिये अधिक सुविधा मिल सकेगी। साथ-साथ

यह भी सुभाव है कि विज्ञान विषय का अध्ययन करने वालों के लिये सामान्य विज्ञान व क्राफ्ट के विषय का अध्ययन भी उचित समझकर हटाया जा सकता है। इससे भी विज्ञान के अध्ययन में अधिक समय मिल सकेगा। इसके साथ-साथ यदि बालकों को विद्यालयों के बाहर जाकर संबंधित क्षेत्रों में निरीक्षण व प्रयोग की सुविधा दी जाय तो इससे बालक विज्ञान का जीवन से संबंध व उसके अध्ययन की मुख्यता को समझते हुए उसमें अधिक रुचि ले सकेगा। इसके अतिरिक्त विज्ञान से संबंधित क्षेत्रों में कार्य करने की योजनाएं बनाकर उन पर भी उसी प्रकार अमल किया जा सकता है जैसे अनुसंधान के कार्य में किया जाता है। इससे प्रत्येक बालक में अनुसंधान करने की प्रवृत्ति तो बढ़ेगी ही परन्तु वह इस क्षेत्र में कार्य करता हुआ समाज के लिये अधिक उपयोगी भी सिद्ध हो सकेगा।

विज्ञान का पाठ्यक्रम आज भी वही है जो २५ वर्ष व उससे पूर्व था। आज विज्ञान के क्षेत्र में इतनी उन्नति हुई है कि साधारण रूप में उसका आवश्यक ज्ञान सबके लिये अत्यावश्यक है। राजस्थान में बनस्पति, खेती, पशुपालन और कुछ स्थानों पर खनिज पदार्थों से संबंधित विषय को विज्ञान के पाठ्यक्रम में विशेष स्थान मिलना चाहिये। इससे प्रत्येक बालक को वास्तविक परिस्थितियों के अध्ययन की सुविधायें प्राप्त हो सकेंगी। आज विज्ञान का पाठ्यक्रम बहुत ही कठिन व रूखा प्रतीत होता है इससे बालक वैज्ञानिक दृष्टिकोण व वैज्ञानिक प्रणाली पर कार्य करने की क्षमता प्राप्त करने में असमर्थ रहता है। बालक स्वास्थ्य विज्ञान का अध्ययन करता है परन्तु देखा जाता है कि वह उसके सिद्धान्तों से बहुत दूर है।

देवीसिंह कछवाहा : अध्ययन और समस्याएँ

आज भी बालक चेचक का टीका न लगवाकर पूजा में अधिक विश्वास रखता है, आज भी समाज बीमारी या सर्पदंश पर दवाइयों पर विश्वास न रख कर मंत्र व पूजा में विश्वास रखता है। इन सभी परिस्थितियों को उचित शिक्षा द्वारा बदला जा सकता है। आज आवश्यकता है कि विज्ञान विषय का पाठ्यक्रम जीवन से अधिक संबंधित हो ताकि उसका पूर्ण उपयोग हो सके व देश की वर्तमान समस्याओं को हल करने में सहायता मिल सके।

आज विज्ञान-क्लब, अध्ययन गोष्ठियाँ, व प्रोजेक्ट का आयोजन करने में उत्साह व रुचि नहीं है। विद्यालयों में इतना समय नहीं मिलता कि इन क्रीड़ाओं की तरफ विशेष ध्यान दिया जा सके। विद्यालय में पूरे समय तक विभिन्न कक्षाओं को पढ़ाना, लिखित कार्य कराना, जाँच करना, प्रयोग, खेलकूद व स्काउटिंग, सांस्कृतिक आदि आदि इतनी क्रीड़ाएँ रहती हैं कि अध्यापक विज्ञान-क्लब या प्रोजेक्ट पर कार्य करने का समय नहीं बचा पाता। यदि वास्तव में इस प्रकार योजनाएँ बनाकर बालक का मानसिक विकास करना है तो उसके लिये अलग से समय निकालना होगा, आर्थिक कठिनाइयों को भी दूर करने के लिये सोचना होगा। आज शिक्षण के क्षेत्र में इन अतिरिक्त क्रीड़ाओं का एक विशेष महत्व है और हमको हमारे बालकों को उचित शिक्षा देने हेतु यह सुविधायें उपलब्ध करनी होंगी।

विज्ञान विषय के पढ़ाने हेतु अध्यापकों की कमी भी एक विशेष समस्या है। शिक्षा के विस्तार के साथ साथ विज्ञान पढ़ाने वाली शालाओं की बहुत वृद्धि हुई है परन्तु वहाँ पर

इन विषयों को पढ़ाने के लिये अध्यापकों की कमी है। कभी कभी तो महीनों तक एक कक्षा बिना विज्ञान अध्यापक के चलती है। फलस्वरूप विज्ञान विषय के उद्देश्यों की प्राप्ति नहीं हो पाती बल्कि इससे उल्टी कुछ हानि ही हो सकती है। विज्ञान अध्यापकों के लिये राज्य सरकार ने काफी आकर्षक वेतन श्रृंखला रखी है व बी० एड०, एम० एड० का प्रशिक्षण प्राप्त करने पर विशेष वृद्धि का आयोजन रखा है फिर भी अध्यापकों की कमी पूरी होने में समय लगेगा। ग्राम्य क्षेत्र की स्कूलों में जहाँ विज्ञान का अध्ययन होता है, यह समस्या और भी अधिक गम्भीर है।

विज्ञान शिक्षा के उद्देश्यों, पाठ्यक्रम, पाठन विधियाँ और मूल्यांकन विधियों में समन्वय नहीं होने के कारण भी कुछ समस्याएँ बन गई हैं। सर्वप्रथम आज का विद्यार्थी केवल परीक्षा उत्तीर्ण करने में केन्द्रित रहता है। चयनात्मक अध्ययन, और बाजार में मिलने वाली सस्ती कुँजियों की सहायता प्राप्त कर वह विज्ञान विषयों में सफलता प्राप्त कर लेता है। इससे शिक्षा के उद्देश्यों की प्राप्ति नहीं हो पाती है। आज बालक का मूल्यांकन केवल लिखित या प्रायोगिक परीक्षाओं द्वारा ही होता है। यह परीक्षाएँ बालक के पूर्ण विकास का मूल्यांकन करने में असमर्थ हैं। बालक अपनी कक्षा और उसके बाहर किस प्रकार वैज्ञानिक प्रणालियों के आधार पर अपने ज्ञान में वृद्धि कर सकता है उसका इस परीक्षा प्रणाली से कोई संबंध नहीं है। अध्यापक भी यह जानता है कि केवल परिणाम के प्रतिशत से ही जब यश प्राप्त किया जा सकता है तो विषय की गहराइयों में जाकर बालक को शिक्षित

करने का अतिरिक्त श्रम क्यों किया जाय। इसके अतिरिक्त यह भी सच है कि आज विज्ञान का अध्ययन बहुत ही पुरानी पद्धतियों पर ही चल रहा है। बालक में सोचने, समझने, निरीक्षण करने, प्रयोग, निष्कर्ष व जाँच करने की प्रवृत्तियों को जागृत नहीं किया जाता है। आज सभी कक्षाओं में वही पाठ्यक्रम चल रहा है जो बहुत समय पहले था। छोटी कक्षाओं में सामान्य विज्ञान में थोड़ी हाईजिन, कुछ भौतिक रसायन व वनस्पति शास्त्र का पुस्तकीय ज्ञान दे दिया जाता है। यदि इनके स्थान पर उसके जीवन और सामाजिक आवश्यकताओं के आधार पर इस विषय का प्रायोगिक ज्ञान दिया जाय तो उससे अधिक लाभ की सम्भावना है। आज बालक कक्षाओं में केवल चाक व श्यामपट्ट की सहायता से विज्ञान पढ़ता है जबकि आवश्यकता है कि उसे यथार्थ व प्रायोगिक रूप में उसके समक्ष रखा जाय। इस संबंधित अच्छी फिल्म, पाठन सामग्री की भी पूरी पूरी आवश्यकता है ताकि बालक की रुचि बढ़ सके।

वर्तमान युग में विज्ञान का अध्ययन बहुत ही महत्वपूर्ण बन रहा है। आज केवल अनुसंधान करने वाले, कुछ त्विनकी इंजिनियर्स व डाक्टर ही तैयार नहीं करने हैं बल्कि आवश्यकता है कि जीवन के प्रत्येक मूल्य का गहरा संबंध इस विषय से किया जाय ताकि आम लोग विज्ञान के सिद्धान्त को समझें और अपने जीवन को सुखमय और सफल बना सकें। आज राष्ट्र की विभिन्न समस्याओं का हल इसी पर निर्भर है कि विज्ञान का पाठ्यक्रम राष्ट्र की आवश्यकताओं के अनुकूल हो और उसका अध्यापन इतना सजीव हो कि प्रत्येक बालक और बालिका का

पूर्ण व्यक्तित्व उभर उठे और यह वैज्ञानिक प्रणाली को सीख कर एक अनुसंधान करने वाला बन सके।

—देवीसिंह कछवाहा

प्राकृतिक विद्याओं की प्रगतिशील पाठ्यचर्या

हमारे देश में प्राकृतिक विद्याओं (Natural Sciences) की शिक्षण संबंधी अनेक समस्याओं में पाठ्यचर्या की समस्या प्रमुख है, क्योंकि यथावत् पाठ्यचर्या निर्माण से एक ओर तो शिक्षकों में उत्साहवृद्धि की जा सकती है, दूसरी ओर विद्यार्थी वर्ग को अनेक हानियों से बचा लिया जा सकता है। जिस प्रकार पिता की सम्पत्ति का पुत्र अधिकारी समझा जाता है, ऐसी ही स्थिति ज्ञानार्जन में है। मानव समाज की पूर्वपीढ़ियों ने प्रकृति के जो मूलभूत रहस्य उद्घाटित किये हैं, तथा इस समय जो नवीनतम अनुसंधान व आविष्कार किये जा रहे हैं, इनका ज्ञान विद्यार्थी को तत्काल कराना महत् अनिवार्य है। यदि वृद्धित प्राकृतिक ज्ञान के अनुसार पाठ्यचर्या में परिवर्तन व परिवर्द्धन नहीं किया जाता है, तो सत्यान्वेषियों द्वारा ज्ञान ज्योति प्रज्वलित करने के लिये जो प्रयास हो रहा है उसमें अवरोध उत्पन्न करने का दोष शिक्षा शास्त्रियों पर आता है।

हमारे देश में प्राकृतिक विद्याओं की पाठ्यचर्या की दशा उसी प्रकार की है जिस प्रकार की दशा हमारे विश्वविद्यालयों की है। प्राथमिक कक्षाओं की पाठ्यचर्या शिक्षा विभाग द्वारा, माध्यमिक कक्षाओं की पाठ्यचर्या शिक्षा मण्डल

द्वारा निर्मित होती है, तथा अनुसंधान विद्यालय में खोज संबंधी कार्य चलता है। विश्वविद्यालयों के पास मात्र पूर्व व उत्तर स्नातकीय कक्षाओं की पाठ्यचर्या का निर्माण रह जाता है। हालांकि अब विश्वविद्यालय में अनुसंधान की ओर ध्यान दिया जाने लगा है, फिर भी अधिकांश अनुसंधान विद्यालय विश्वविद्यालयों से अलग ही हैं। किसी मनुष्य के पाद, उदर, वक्ष व शिर भिन्न-भिन्न करने पर जो उसकी स्थिति होगी यही स्थिति विश्वविद्यालयों की है, तथा ठीक वैसी ही चिंतनीय दशा प्राकृतिक विद्याओं की पाठ्यचर्या की है।

भौतिकशास्त्र, गणित आदि विषयों में विदेशों में इस गति से अनुसंधान हो रहे हैं कि प्रत्येक दशाब्दि में पाठ्यचर्या में परिवर्द्धन व परिवर्तन करना होता है। इधर हमारे विश्वविद्यालयों द्वारा निर्मित स्नातकीय कक्षाओं के पाठ्यक्रम अन्तराष्ट्रीय स्तर से न्यूनतम दश वर्ष तो पीछे होते ही हैं। हमारे देश में अनुसंधान कार्य के लिये जिस उत्साह का अभाव दीख पड़ता है उसमें एक मुख्य कारण पाठ्यचर्या को परिष्कृत न करना भी है।

सामान्य प्राकृतिक ज्ञान (General Natural Science) संबंधी पाठ्यचर्या (माध्यमिक व स्नातकीय स्तर) को देखने से ज्ञात होगा कि इसमें पुनरुक्ति दोष अत्यधिक है। कक्षा आठ तक जो जानकारी भौतिकी, खगोलशास्त्र आदि की दी जाती है, इसी को कक्षा दस में रख दिया जाता है। कक्षा दस की पाठ्यचर्या में नई बातों का समावेश अत्यल्प होता है, तथा कक्षा दस तक की अधिकांश बातें

उतने ही विस्तार में कक्षा बारह तेरह की पुस्तकों में मिल जायेंगी। इसी प्रकार की अशुद्धि भौतिक शास्त्र, गणित शास्त्र आदि विषयों में भी मिलेगी। अतः प्रथम प्रयास पुनरुक्ति दोष से विद्यार्थी को बचाना हो ताकि अल्प समय में उन्हें नवीनतम व अधिकतम ज्ञान दिया जा सके।

वर्तमान समय में जिस प्रकार के अनुसंधान व आविष्कार हो रहे हैं, उसे दृष्टिगत रखते हुए पूरा ध्यान रखा जाना चाहिये कि जो सिद्धान्त व आविष्कार क्रान्तिकारी परिवर्तन लाने वाले सिद्ध हुए हैं, इन्हें पाठ्यचर्या में अधिक विस्तार मिले। गुरुत्वाकर्षण व विद्युत्-चुम्बकत्व संबंधी कतिपय सिद्धान्तों को माध्यमिक कक्षाओं में विस्तार दिया जाता है तथा सापेक्षवाद (Theory of relativity) आदि जैसे सिद्धान्तों की चर्चा माध्यमिक भौतिक शास्त्र की पाठ्यचर्या में नहीं होती, जब कि भौतिक शास्त्र का जगत सापेक्षवाद से कहीं बहुत आगे चला गया है। माध्यमिक भौतिक शास्त्र में विमान शास्त्र (Aeronautics) संबंधी जानकारी न के बराबर होती है। इधर प्रकृतिवेत्ता (Natural Scientists) विभिन्न प्रकार के राकेटों की सहायता से चन्द्रमा व मंगल की ओर जाने का अथक प्रयास कर रहे हैं।

भौतिक शास्त्र में अनेक शिक्षा मंडल (Boards of Education), आदि यांत्रिक विद्या (Mechanics), उष्मा, प्रकाश एक साथ तथा विद्युत्-चुम्बकत्व, ध्वनि एक साथ रखते हैं जो कि अनुचित है। अनेक शिक्षा मंडल यांत्रिकी के साथ उष्मा, ध्वनि तथा विद्युत्-चुम्बकत्व के साथ प्रकाश रखते हैं जो कि पहले से ठीक है,

परंतु यांत्रिकी के साथ विद्युत्-चुम्बकत्व व प्रकाश के साथ उष्मा, ध्वनि रखना अधिक संगत है। गुरुत्वाकर्षण व विद्युत्-चुम्बकत्व में अधिक समीपता है। चुम्बकीय बल रेखायें माध्यमिक कक्षाओं में बता दी जाती हैं, पूर्वस्नातकीय कक्षाओं में विद्युतीय बल रेखा व उत्तरस्नातक कक्षाओं में गुरुत्वाकर्षणीय बल रेखायें बताई जाती हैं जबकि इनमें समता है। इन सबको एक पत्र में रखा जाय तो तीनों की बल रेखाओं का ज्ञान माध्यमिक कक्षाओं में ही दिया जा सकता है। परावर्तन, आवर्तन, विवर्तन, व्यतिकरण आदि क्रियाएं प्रकाश, उष्मा, ध्वनि तीनों में होती हैं। प्रकाश संबंधी परावर्तन माध्यमिक कक्षाओं में व उष्मा और ध्वनि संबंधी परावर्तन पूर्वस्नातकीय कक्षाओं में पढ़ाया जाता है। एक ही पत्र में रख देने पर माध्यमिक कक्षाओं में ही यह जानकारी दी जा सकती है।

स्नातकीय भौतिक शास्त्र में पूर्वस्नातक कक्षाओं में वर्तमान भौतिक शास्त्र का स्थान अनेक विश्वविद्यालयों में अत्यल्प है। भौतिक शास्त्र की पाठ्यचर्या को व्यवस्थित रूप दे देने से समस्या हल हो जायगी। इसके लिए उत्तरस्नातकीय भौतिक शास्त्र की पाठ्यचर्या को ऐसा व्यवस्थित बनाना होगा कि जो भी वर्तमान उन्नति हो रही है वह समय-समय सम्मिलित की जा सके। भौतिक शास्त्र व गणित की पाठ्यचर्या में एक-एक विशेष परिवर्तन और करना होगा। पूर्वस्नातकीय कक्षाओं में और उत्तरस्नातकीय कक्षाओं में गणित के साथ यांत्रिकी भी पढ़ाई जाती है। गणित में उत्तरस्नातक कक्षाओं में विद्युत्-चुम्बकत्व आदि के पत्र भी रख दिये जाते हैं। अच्छा हो यदि पूर्वस्नातकीय गणित में यांत्रिकी

न पढ़ाई जाय तथा उत्तरस्नातकीय कक्षाओं में गणित के अनिवार्य पत्रों में न हो, बैकल्पिक पत्रों में यांत्रिकी व विद्युत्-चुम्बकत्व, सापेक्षवाद, आदि रखे जायें। पदार्थगत यांत्रिक गुण (Mechanical properties of matter) को गणित में यांत्रिकी (Mechanics) व भौतिक शास्त्र में पदार्थगत गुण (Properties of matter) नाम से पढ़ाया जाता है, माध्यमिक कक्षाओं में तो इसे सामान्य भौतिकी (General Physics) जैसा रद्दी नाम दे दिया गया है। इसे व्यवस्थित व क्रमबद्ध रूप देकर भौतिक शास्त्र में ही रखना अध्ययन के लिये उपयोगी होगा, तथा गणित में पूर्वस्नातक कक्षाओं में व उत्तरस्नातक कक्षाओं में अनिवार्य पत्रों से यांत्रिकी को हटाने से एक बड़ा लाभ यह होगा कि इसके स्थान पर गणित में नवीन सिद्धान्तों को समाविष्ट किया जा सकेगा या प्राच्य सिद्धान्तों का वर्द्धन हो सकेगा। उत्तरस्नातक गणित में कोई बीस अंगों को स्थान दिया जा सकता है। तथा ऐसी पाठ्यचर्या से उत्तीर्ण गणित स्नातक भौतिक शास्त्र व अभियांत्रिकी (Engineering) के लिये आवश्यक गणित का अध्यापन सरलता से करा सकेंगे।

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किसी सिद्धान्त के सूत्रगत सिद्धि संबंधी अनेक प्रयोग पाठ्यचर्या में रख दिये जाते हैं। सूर्यकान्तमणि (Lens) का नाभ्यांतर निकालने के लिये दश विधियाँ पढ़ाकर क्यों विद्यार्थी का अमूल्य समय नष्ट किया जाय? कितना अच्छा हो कि जो सर्वोत्तम विधि है उसे ही पाठ्यचर्या में रख दिया जाय। गुरुत्वाकर्षण नियतांक या

‘रिक्त’ प्राकृतिक विद्याओं की पाठ्यचर्या

विद्युत्-चुम्बकीय नियतांक, प्रकाशवेग आदि सब के लिये सर्वोत्तम विधियों को ही बताना अधिक लाभकारी होगा, ताकि पाठ्यचर्या में नवीन अर्जित ज्ञान का समावेश किया जा सके।

गणित की पाठ्यचर्या में व्यापकता के महत्व को अभी तक भुलाया जा रहा है। माध्यमिक गणित की तो बात ही छोड़िये, स्नातकीय रेखा-गणित में यूक्लीडीयैतर (Non Euclidean) विचारों को कोई स्थान नहीं। उत्तरस्नातक कक्षा के विद्यार्थियों को अनेक विस्तारयुक्त (N dimensional) रेखा गणित की कोई जानकारी नहीं तथा इन कक्षाओं में रीमां (Riemannian) रेखा-गणित का आरम्भिक ज्ञान भी नहीं कराया जाता तब मिंगोवस्की (Mingovaski) के विचारों को स्थान मिलने की क्या आशा की जाय? माध्यमिक रेखागणित में केवल यूक्लिड का ही स्थान देकर इसके क्षेत्र को क्यों व्यर्थ ही संकुचित किया जाय। बड़ी ही सरलता के साथ जब कि समांतर-ऋजु रेखायें व त्रिभुज सम्बन्धी यूक्लीडीय स्वयं तथ्य (Axioms) बताये जाते हैं, साथ ही रीमां की स्वयं-सिद्धियाँ भी बतादी जायें तो कोई हानि न होगी। महत्व रेखागणित की स्वयं-सिद्धियों का है, जिनके आधार पर प्रमेय बनते हैं न कि प्रमेयों का व उनकी उपपत्ति का। अतः आवश्यकता के अनुसार प्रमेयों का विस्तार न्यून किया जा सकता है व उनके स्थान पर विस्तार से रेखागणित सम्बन्धी नवीन विचारों को रखा जा सकता है। भौतिक शास्त्र को समझने के लिये ठोस रेखागणित अत्यधिक उपयोगी है जब कि माध्यमिक कक्षाओं में इसके लिये कोई विशेष स्थान नहीं है। इसके अभाव में स्नातक कक्षाओं में जब नियामक (Co-ordinate) ठोस

रेखागणित पढाई जाती है तब विद्यार्थियों को अधिक कठिनाई होती है।

स्नातकीय कक्षाओं में रेखागणित का क्षेत्र केवल शंकु (Conic) वक्र व तलों का अध्ययन कराकर व्यर्थ ही क्यों उसे संकुचित रखा जाये ? अनेक प्रकार के वक्रों को चलनकलन-गणित (Calculus) जो कि बीजगणित का सूक्ष्मरूप है, के साथ रखा जाता है, जब कि उन्हें रेखागणित की पाठ्यचर्या में रखना अधिक उपयुक्त होगा तथा गोलीय नियामक (Spherical Co-ordinates) को अधिक स्थान नहीं दिया जाता, जबकि गोलीय नियामक गणितज्ञ के लिये अधिक प्रभावकारी साधन हैं, जैसे कि बीजगणित की अपेक्षा तृतीय बीजगणित (Trigonometry) अधिक प्रभावकारी है तथा गतीय रेखागणित (Kinematics) को यांत्रिकी के साथ रखा हुआ है, जब कि इसे भी रेखागणित में ही रखा जाना चाहिये। ऐसा करने से बीजगणित (जो कि भिन्न-भिन्न रूपों में अधिक विकसित हो चुकी है) की पाठ्यचर्या को विस्तार दिया जा सकेगा।

उपयुक्त परिवर्तन करने के लिये यदि विश्व-विद्यालय आदि अग्रेसर हों तो निश्चय ही कुछ ही समय में अन्तर्राष्ट्रीय स्तर पर पहुँचा जा सकता है। इसी प्रकार अन्य विषयों के पाठ्यक्रम में परिवर्तन करने से अध्यापक को परिश्रम अधिक करना होगा, जिसका व्यवस्थित प्रबन्ध विश्वविद्यालयों द्वारा किया जा सकता है परन्तु इसका रूप वर्तमान ग्रीष्मकालीन विद्यालयों (Summer Institutes) से अलग प्रकार का होगा। साथ ही हमें प्राकृतिक विद्याओं

सम्बन्धी जानकारी जो संस्कृत ग्रंथों में प्राप्य है उसका भी पूरा लाभ उठाना चाहिये। प्राकृतिक विद्या का प्राचीन नाम ज्योतिष है। ज्योतिष का अर्थ संकुचित अर्थों में खगोल शास्त्र किया जाता है। वस्तुतः ज्योतिष ग्रंथों में गणित, भौतिक-शास्त्र खगोल शास्त्र आदि सब हैं।

आयुर्वेदीय रसायन शास्त्र में पारद व स्वर्ण भस्म तथा इसके जटिल यौगिकों का निर्माण नागार्जुन जैसे आयुर्वेदज्ञ ने कर लिया था। आयुर्वेद ग्रंथों में वनस्पति, पशु व मनुष्य सबके लिये स्वास्थ्य व चिकित्सा सम्बन्धी ज्ञान का उल्लेख है। शल्य चिकित्सा में सुश्रुत वर्णित नेत्राध्याय में ऐसे यंत्रों का वर्णन है जो खड़े बाल के दो भाग कर सकते हैं। तात्पर्य यह है कि हमारा विद्यार्थी नवीनतम ज्ञान से परिचित हो साथ ही प्राचीनतम प्रकृति सम्बन्धी प्राप्य ज्ञान भी उसको प्राप्त हो जाय ताकि प्रारम्भ से लेकर अब तक मनुष्य ने प्रकृति के सम्बन्ध में जो जानकारी प्राप्त की वह विद्यार्थी से छिपी न रहे।

यांत्रिक शिल्प में भारद्वाज प्रणीत विमान-शास्त्र प्राप्य है, जिसमें विद्युत् व पारद चलित विमानों का वर्णन है, तथा ऐसे यंत्रों का संकेत है जो अंतरिक्ष में जाने में समर्थ हैं। संस्कृत ग्रंथों में धातु-विद्या की उच्चकोटिता का अनुमान अशोक की लाट से किया जा सकता है।

भौतिक शास्त्र के सम्बन्ध में भास्कर ने गति नियमत्रयी (Three laws of motion) भी बताई है। बराह मिहिर ने बृहत् संहिता में गुह्यवा-कर्षण सिद्धान्त की पुष्टि की है, तथा खगोल के साथ भूतत्त्व शास्त्र का भी विस्तृत वर्णन किया

है। भौतिक शास्त्र की नवीनतम समस्याओं का हल हमें इन ग्रंथों में मिल जायेगा। भाव मिश्र ने बता दिया था कि प्रकाश व उष्मा कण-निर्मित हैं, तथा वैशेषिक शास्त्र के अनुसार द्रव्य व उर्जा रूपान्तरित होते हैं, आवश्यकता यह है कि वैशेषिक के पंचभूतों का तात्पर्य समझ लिया जाय। वैशेषिक का 'पृथ्वी द्रव्य की कण अवस्था है तथा 'जल' धारावस्था है, अग्नि उर्जा तथा महामति एडिंगटन ने जिसे वैविकल (Waveicle) कहा है वह 'वायु' है। 'आकाश' का अर्थ विस्तार युक्त स्थान है।

गणित में भास्कर ने 'सिद्धान्त शिरोमणि' में बीजगणित, वृत्तीय बीजगणित, कलनगणित, रेखागणित आदि सभी के मूल सिद्धान्त रखे हैं तथा सूर्य सिद्धान्त व वेदांग ज्योतिष आदि में प्राकृतिक विद्याओं सम्बन्धी गम्भीर सामग्री है।

प्राकृतिक ज्ञान के साथ मनस् शास्त्र आदि का उल्लेख विस्तार भय से नहीं किया गया है। पाठ्यचर्या में सुधार करने के लिये योजनाबद्ध सम्मिलित प्रयत्न करने की महती आवश्यकता है। इसके लिये एक और संस्कृत ग्रंथों की खोज व अनुवाद का प्रबन्ध करना होगा, दूसरी ओर जर्मन, रूसी, फ्रांसीसी, अंग्रेजी, चीनी, जापानी आदि भाषाओं में लिखित ग्रंथों का अनुवाद करना होगा। विश्व के प्रगतिशील विश्वविद्यालयों की पाठ्यचर्याओं का अध्ययन करके उत्साही शिक्षकों द्वारा जो पाठ्यचर्या निर्मित की जायगी वह प्रगतिशील पाठ्यचर्या होगी। जो शिक्षक व विद्यार्थी में उत्साहपूर्वक वृद्धि के साथ उनकी मौलिक विचारवृत्ति को उन्नत कर अनुसन्धान-वर्द्धन में सहायक होगी ताकि आगे हम विदेशों की नकल ही न करते

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रहें, वरन् स्वयं भी ज्ञान का उद्भव करने में समर्थ हों और पहले की भाँति प्राकृतिक विद्या सम्बन्धी धुरन्धर विद्वान् विश्व को दे सकें।

—'रक्षक'

विज्ञान अध्यापन में वातावरण का उपयोग

आज के जन जीवन में विचारों की क्रान्ति का मूल विज्ञान के आविष्कार हैं। इन के कारण मानव की भ्रान्त धारणाओं का किला धराशायी हो रहा है। जीवन के हर पहलू को मानव वैज्ञानिक दृष्टिकोण से परखने को उत्सुक है। वह अन्धविश्वासों की लोह शृंखला को तोड़ कर जीवन और प्रकृति के रहस्य को जानने के लिए विज्ञान के साथ कदम मिला रहा है। प्राचीन मान्यताओं, जन-श्रुतियों व विश्वासों को वैज्ञानिक कसौटी पर कसकर उनका सही आधार ढूँढ़ना चाहता है।

अतः जीवन के प्रत्येक क्षण व क्षेत्र में विज्ञान के बढ़ते चरण देखकर आज विज्ञान का एक विषय के रूप में अध्ययन व अध्यापन एक विशेष महत्व रखता है। इस देश में इसके अध्ययन व अध्यापन की सुविधाओं का अविलम्ब विस्तार होना आवश्यक है। इसके अध्यापन की परम्परागत प्रणाली में उपकरण, यंत्र व सुसज्जित प्रयोगशाला भवनों की आवश्यकता होती है। इस नव विकासोन्मुख देश के सीमित साधन इस लक्ष्य को द्रुत गति से प्राप्त करने में बाधक हैं।

अतः विज्ञान के अध्यापन की विधि में आमूलचूल परिवर्तन विचारणीय हैं।

आप एक शिशु के क्रियाकलापों का निरीक्षण करने पर अनुभव करेंगे कि वह प्रत्येक वस्तु को निरख परख कर उसके सम्बन्ध का ज्ञान प्राप्त करने के लिए कैसा अधिक परिश्रम करता है? शिशु के इन क्रियाकलापों को हम खेल की संज्ञा देते हैं। लेकिन यही खेल उसके प्रारम्भिक वैज्ञानिक प्रयोग हैं, और आसपास का वातावरण है उसकी आकर्षक प्रयोगशाला। जहाँ अनेकों भौतिक व रासायनिक परिवर्तन, क्रियाएँ व प्रयोग उसका ध्यान आकर्षित कर रहे हैं। आवश्यकता है बालक के सही वैज्ञानिक दृष्टिकोण का विकास करने की जो इन परिवर्तनों, क्रियाओं व प्रयोगों से निष्कर्ष निकाल सके, एक एक करके परिणामों को आत्मसात् कर अपने ज्ञान भंडार का अभिवर्द्धन कर सके।

बालक छोटे छोटे पक्षियों, जीवजन्तुओं, कीड़े-मकोड़ों को विविध क्रियाकलाप करता हुआ बड़े चाव से देखता है और उनके सम्बन्ध में अपनी धारणाएँ बनाना आरम्भ कर देता है। इन धारणाओं को सही दिशा व रूप देकर सँवारना विज्ञान अध्ययन का कार्य है। इस प्रकार बालक की क्यों और कैसे की जिज्ञासा शनैः शनैः प्रबल होती है और उसकी ज्ञान पिपासा बढ़ती है।

विज्ञान के अध्यापन में इसी प्रारम्भिक ज्ञान पर हम विज्ञान अध्यापक अपने अध्यापन पाठ को आधारित करते हैं। बालकों के इसी पूर्व ज्ञान से उदाहरण देकर हम अपने अध्यापन पाठ को इकाई का विकास करते हैं।

विज्ञान अध्यापक का यह कर्तव्य है कि वह बालक की इस प्रवृत्ति को प्रोत्साहित कर सृजन करे ताकि प्रकृति के इन क्रियाकलापों व रहस्यों का अध्ययन करना उसका स्वभाव बन जाये।

इस प्रकार हो सकता है इन बालकों में से ही कुछ धुन के पक्के विश्व के भावी न्यूटन और डार्विन बन जायें।

प्रकृति की रम्यता में रंग बिरंगे फूल व पत्तों की ओर आकर्षित होता हुआ बालक सहज ही में उन फूल व पत्तों की बनावट व कार्यों का अध्ययन कर सकता है। बहते हुए नदी-नाले उसे भूमि का कटाव, मिट्टी का बहाव, पत्थरों की बिसाई, मिट्टी की बनावट, गन्दगी का बहाव, पानी का तल, पानी के कुछ जीव जन्तुओं के रहने के ढंग आदि को समझाने में सहायक हैं। गिरते हुए भरने कल-कल स्वर में उसे उनके जल में निहित शक्ति का आभास कराते हैं जिससे कल अनेकों कल चल सकेंगे। नदी पर बँधे बाँध, नहरों का निकास व सिंचाई के समय जल का प्रवाह, वह स्वयं आँखों से देख कर ही अच्छी तरह समझता है।

सप्तरंगी इन्द्रधनुष, वर्षा का होना, आर्द्रता का प्रभाव, ओले, हिमपात, आंधी, तूफान व तड़ित को बालक जब अनुकूल मौसम में देखता है तो उसकी बढ़ी हुई जिज्ञासा के कारण अध्यापन पाठ की इकाई अत्यन्त सफलता पूर्वक पढ़ाई जा सकती है।

आकाशीय पिंडों की पहचान, उनकी गति का आभास तो रात के स्वच्छ आकाश में ही संभव है। प्रचलित जनश्रुति व अन्ध-विश्वास के निराकरण के लिए सूर्य व चन्द्रग्रहण होता हुआ दिखना आवश्यक है। प्रकाश का आवर्तन, परावर्तन, बिम्बों का बनना, धूपघड़ी आदि के अनेकों प्रयोग सूर्य के प्रकाश में सुविधा पूर्वक दिखाये जा सकते हैं।

चिड़ियों को घोंसले बनाते, अण्डों से निकले बच्चों को दाना खिलाते देखकर बालक आकर्षित होता है, उसकी उत्सुकता बढ़ती है। बया, कबूतर, भारत के राष्ट्रीय पक्षी मोर व अन्य पक्षियों के घोंसलों में जो अन्तर है बालक उनका कारण जानना चाहता है। इसी प्रकार, वृहे, बन्दर, बिल्ली, कुत्ते, गाय, भैंस, भेड़, बकरी, ऊँट, गधे, घोड़े आदि पशुओं के क्रियाकलापों व रहन सहन (Habit and Habitat) को बालक बड़े चाव से देखता है, उसके मस्तिष्क में अनेकों भाव उठते हैं। वह क्यों और कैसे के उत्तर चाहता है। यहाँ उसे विज्ञान अध्यापन का अवलम्ब कितना लाभदायक सिद्ध हो सकता है।

प्रकृति (Flora and Fauna) तो अध्ययन की सामग्री का अनन्त भंडार है पर घर व समाज में भी अध्ययन हेतु पर्याप्त सामग्री है। घर में काम में आने वाले मिट्टी के घड़ों में पानी का ठंडा होना, बर्फ को बुरादे या टाट में लपेटना, कैची, थर्मस, लालटेन, स्टोव, इलेक्ट्रिक प्रेस, हीटर, कांच, टार्च, टेलिफोन, बिजली की घंटी, घड़ी, सिलाई मशीन, रेडियो, बल्ब, साबुन, सोडा आदि उपकरणों व सामग्री का उपयोग शहरी बच्चों में क्यों और कैसे की जिज्ञासा उत्पन्न करता ही है।

गाँव का बच्चा खेत में कुओं पर चलते रहँट, डेकली, हल, ट्रैक्टर, मोटर, कुटी की मशीन आदि को देखकर स्वाभाविक प्रश्न पूछता है व समाधान की आशा रखता है।

अतः गाँव हो या शहर दोनों ही के प्राकृतिक और सामाजिक वातावरण में विज्ञान के अध्ययन और अध्यापन हेतु सामग्री की कमी नहीं है।

विज्ञान की शिक्षा में इस सामग्री का उपयोग करने के लिए निम्नलिखित सुझाव विचारणीय हैं :-

१. विज्ञान शिक्षा के पाठ्यक्रम को पुनर्गठित कर लोचदार बनाया जाये। उसमें प्राकृतिक एवं सामाजिक वातावरण में घटित वैज्ञानिक घटनाओं का अधिकाधिक समावेश हो।

२. पाठ्य-पुस्तकों में बालक के आसपास के वातावरण में घटित घटनाओं के उदाहरण द्वारा विषय को समझाने का प्रयत्न किया जाये।

३. पाठ की इकाइयों का क्रम मौसम, प्रकृति, परिस्थिति एवं वातावरण के अनुकूल रखने की सुविधा हो।

४. प्रत्येक पाठ के अध्यापन से पूर्व बाह्यभ्रमण (Field Trip) एवं प्रकृति अध्ययन द्वारा सम्बन्धित जानकारी संकलित की जाये। छात्र व छात्राओं द्वारा इस प्रकार स्वयं अनुभव की गई जानकारी पाठ की इकाइयों का आधार हो। बाह्यभ्रमण में खेत, उद्यान, वन, उपवन, घाटी, नदी, नहर, तालाब, झील, सागर, बाँध, का भ्रमण ही नहीं कारखाने, मिल, बिजलीघर, जलप्रदाय, रेडियो स्टेशन, अजायबघर, प्रदर्शनी, संग्रहालय का अवलोकन भी सम्मिलित है।

५. प्रत्येक विद्यालय में संग्रहालय की व्यवस्था हो जहाँ विद्यार्थियों द्वारा संकलित वस्तुएँ एवं उनके द्वारा निर्मित यंत्रों के मॉडल रखे जा सकें।

६. प्रत्येक विद्यालय में छात्र-छात्राओं द्वारा उगाये गये पौधों व पाले हुए पशु-पक्षियों के रखने की सुविधा हो व विद्यार्थियों को इस ओर प्रोत्साहन मिले।

७. इस सम्बन्ध में प्रकाशित विदेशी पुस्तकों का सस्ता प्रकाशन स्वदेश की प्रादेशिक भाषाओं में किया जाये ताकि विज्ञान अध्यापक व विद्यार्थी विदेशों के अनुभव से लाभ उठा सकें।

अतः हम निस्संकोच कह सकते हैं कि प्राकृतिक एवं सामाजिक वातावरण में विज्ञान शिक्षा के लिए सामग्री प्रचुर मात्रा में है। बालक अपनी मूल प्रवृत्तियों के कारण पाँचों ज्ञानेन्द्रियों द्वारा इस सामग्री को बड़े चाव से निहारता है। विज्ञान अध्यापक बालक के अनुभवों को इस प्रकार सँवारे कि विद्यार्थी में सही वैज्ञानिक दृष्टिकोण का विकास हो। बाह्यभ्रमण, संकलन व संग्रह इस लक्ष्य प्राप्ति में सहायक हैं। इस दृष्टि से विज्ञान शिक्षा के पाठ्यक्रम को पुनर्गठित कर नया रूप देना आवश्यक है।

—हरिनंदन मिश्र

विज्ञान शिक्षण में सहायक सामग्री का स्थान

सफल विज्ञान शिक्षण के लिये यह आवश्यक है कि अध्यापक द्वारा प्रतिपादित विचार और भाव बालक भली-भाँति समझ सके। सहायक सामग्री न केवल पाठ में रोचकता उत्पन्न करती है और बालकों का ध्यान पाठ की ओर आकर्षित करने में योग देती है बल्कि इससे ज्ञान निश्चित एवं सुदृढ़ हो जाता है। पाठ में कभी-कभी कुछ ऐसी सूक्ष्म बातें भी होती हैं जिनका समझना सबके लिये कठिन नहीं तो कुछ के लिये अवश्य असंभव होता है। सहायक सामग्री यहाँ उपयोगी सिद्ध होती है। जो बातें बालक सुनते हैं, उसे

वे आँख से भी देख लेते हैं। इससे ज्ञान स्थायी हो जाता है। इस प्रकार सहायक सामग्री एक चतुर अध्यापक के शस्त्र (Tools) हैं जिनसे वह शिक्षण को प्रभावशाली, रुचिकर एवं वास्तविक बनाता है।

सहायक सामग्री लाभदायक होती है इसमें कोई दो राय नहीं, पर ध्यान रहे कि इनका उद्देश्य कक्षा का मनोरंजन करना नहीं अपितु कक्षाध्यापन में योग देना है। अतः सामग्री का चुनाव व प्रदर्शन कक्षा के बालकों का मानसिक स्तर एवं उनकी आवश्यकता को दृष्टिगत करके करना चाहिये।

विज्ञान शिक्षण में सहायक सामग्री के कई रूप हो सकते हैं। जैसे :- प्रत्यक्ष वस्तु; चार्ट्स, मॉडल, चित्र, रेखाचित्र, दृश्य श्रवण सामग्री (सिनेमा, मैजिक लैंटर्न आदि) विज्ञान से सम्बन्धित स्थानों का भ्रमण, विज्ञान-सभा (Club) विज्ञान प्रदर्शनी एवं मेलों का आयोजन, रेडियो वार्ता आदि।

प्रत्यक्ष वस्तु — यदि प्रत्यक्ष वस्तु उपलब्ध हो तो उस वस्तु के चित्र की अपेक्षा उस वस्तु का दिखाना अधिक उपयोगी होगा। उदाहरणार्थ :- बैरोमीटर, थर्मस प्लास्क, चुम्बक, मेडक, तितली आदि (पर अत्यन्त परिचित वस्तुएं दिखाकर समय का अपव्यय नहीं करना चाहिये)।

चार्ट्स — ये बाजार से खरीदे हुए भी हो सकते हैं और शाला में निर्मित भी। पर बाजार के निर्मित चार्टों से शाला निर्मित चार्ट एक दृष्टि से अधिक उपयोगी होते हैं। बाजार चार्ट में आवश्यक एवं अनावश्यक सभी बातें होती हैं, जबकि स्वयं निर्मित में आवश्यक बातें ही दिखाई जाती हैं।

चित्र — चित्रों के प्रयोग में यह ध्यान रखना चाहिये कि इनका आकार उचित हो, ताकि सभी बालक ठीक प्रकार देख सकें एवं एक ही चित्र में अनेकों बातें न हों बल्कि (One picture one idea) वाली युक्ति काम में लाई जाय। चित्र ऐसे होने चाहियें, जिनको देखने से उस वस्तु का वास्तविक रूप, रंग, आकार तथा परिमाण का अधिक से अधिक यथार्थ ज्ञान हो सके।

मॉडल — वास्तविक वस्तुएँ जब बहुत बड़ी या बहुत ही छोटी हों और कक्षा में नहीं लाई जा सकें तो मॉडल का उपयोग लाभकारी होता है। जैसे- रेल के इंजिन का कक्षा में लाना दुष्वार है अथवा परमाणु में इलैक्ट्रॉन का संगठन समझाने के लिए वास्तविक परमाणु दिखाना कठिन ही नहीं असंभव भी है तो इलैक्ट्रॉन का तो कहना ही क्या? इसी प्रकार हृदय, मस्तिष्क, फेफड़ों आदि के आकार तो ठीक हैं पर प्रत्यक्ष नहीं दिखाये जा सकते। ऐसी दशा में मॉडल का उपयोग लाभकारी होता है। बाजार से खरीदे गये मॉडल महंगे होते हैं। यदि अध्यापक प्रयास करें तो इन सबका निर्माण बालकों के सहयोग से शाला में ही किया जा सकता है।

शाला में निर्मित उपकरण — इस प्रकार के उपकरण न केवल कम मूल्य में ही बन जाते हैं बल्कि उनके प्रयोग से बालकों का उत्साह वर्द्धन होता है। उन्हें यह देखकर प्रसन्नता होती है कि उनके द्वारा निर्मित उपकरण ही उनके अध्ययन में काम आ रहे हैं।

दृश्य श्रवण सामग्री — शिक्षण की दृष्टि से यह सामग्री अत्यन्त ही महत्वपूर्ण होती है क्योंकि यह बालकों में शीघ्र ही रुचि उत्पन्न करने वाली होती है। पर साथ में बहुमूल्य और खर्चीली

भी होती है। हमारी प्राथमिक एवं माध्यमिक शालाओं को यह दुर्लभ ही प्राप्त होती है। फिर भी इनकी महत्ता व प्रयोग पर कुछ प्रकाश डालना अनुचित नहीं होगा।

इस प्रकार की सामग्री का मुख्य उद्देश्य बालकों में विज्ञान अध्ययन के प्रति रुचि उत्पन्न करना है एवं जो कुछ कक्षा में पढ़ाया गया है उस ज्ञान को फिल्मों द्वारा और अधिक स्पष्ट, उपयोगी एवं सार्थक करना है। अध्यापक फिल्म प्रारम्भ करने से पूर्व उसकी एक संक्षिप्त भूमिका एवं समाप्त होने पर उसका संक्षिप्त सारांश बालकों के समक्ष रख दे। फिल्म अधिक लम्बी नहीं होनी चाहिये अन्यथा लाभ की अपेक्षा हानि होने की अधिक सम्भावना होती है।

मैजिक लैंटर्न, ऐपिस्कोप, ऐपीडायस्कोप, माइक्रो प्रोजेक्टर आदि अन्य ऐसे ही दृश्य श्रवण यंत्र हैं जो अध्यापन को अत्यधिक रुचिकर और लाभदायक बना सकते हैं। इन यंत्रों के द्वारा जू, दीमक, मच्छर, मलेरिया के कीटाणु, लाल एवं श्वेत रक्त-कण आदि को कई गुणा बड़ा करके सम्पूर्ण कक्षा को आसानी से दिखाया जा सकता है।

भ्रमण — बालकों की ज्ञान की अभिवृद्धि के लिये चतुर अध्यापक सदैव ही समाज में उपलब्ध साधनों का अधिक से अधिक उपयोग करने की कोशिश में रहते हैं, क्या शहर और क्या ग्राम! दोनों ही क्षेत्रों में अनेकों शिक्षाप्रद स्थल होते हैं। टेलीफोन एक्सचेंज, रेडियो स्टेशन, अजायबघर, जूलाजिकल व बोटैनिकल उद्यान, साबुन, काँच, व अन्य वस्तुओं के कल कारखाने, हवाई अड्डा, बन्दरगाह, जल एवं विद्युत ग्रह आदि शहरी क्षेत्रों के उदाहरण हैं तो आदर्श कृषि फार्म, दुग्ध

शाला, फलोद्यान आदि ग्रामीण क्षेत्रों के उदाहरण हैं।

इन स्थानों पर भ्रमण केवल 'साइट सीईंग' की दृष्टि से ही नहीं, अपितु शिक्षा के कुछ निश्चित उद्देश्यों की पूर्ति हेतु होना चाहिये जैसे— बालकों में विज्ञान अध्ययन के प्रति अधिक जिज्ञासा, रुचि व प्रेम उत्पन्न करना व कक्षा में दिये गये ज्ञान को अधिक पूर्ण बनाना।

इस प्रकार के भ्रमणों से बालक अनेकों प्रकार से लाभान्वित होते हैं। उन्हें कई महत्वपूर्ण बातों का ज्ञान होता है जो कक्षा में बैठे हुए नहीं हो सकता था। बालकों की निरीक्षण शक्ति, मनन शक्ति एवं तर्कशक्ति का अद्भुत रूप से विकास होता है जो विज्ञान शिक्षण का एक मुख्य उद्देश्य है।

विज्ञान वार्ता— अनुभवी व उच्च विज्ञान-वेत्ताओं द्वारा विज्ञान वार्ताएं भी लाभदायक सिद्ध होती हैं। जिन शालाओं में Radio Sets हैं उन्हें अपने समय-विभाग-चक्र में ऐसी व्यवस्था करनी चाहिये कि जब जब भी इस प्रकार की वार्ताएं प्रसारित की जायें तो उनका लाभ उठाया जाय।

विज्ञान सभा— (Science Club) यह विज्ञान का युग है। विज्ञान की प्रगति हमारी विचार धारा एवं हमारे दैनिक जीवन को पूर्ण-रूपेण प्रभावित किये हुए है। दिन रात हमारा वास्ता छोटी छोटी साधारण विद्युत्तीय और यान्त्रिक वस्तुओं से पड़ता है और हमें छोटी-2 सी खराबियों के लिये मैकेनिक या इलेक्ट्रीशियन के पास दौड़ना पड़ता है जो कि एक बहुत ही दयनीय और हास्यास्पद प्रवृत्ति है। आज प्रत्येक के लिये विज्ञान का ज्ञान जीवन का एक महत्व-

पूर्ण अंग बन गया है। विज्ञान क्लब इस ओर एक महत्वपूर्ण कदम है।

इस प्रकार हम देखते हैं कि उपयुक्त सहायक सामग्री विज्ञान शिक्षण को वास्तविक, यथार्थ, प्रभावशाली एवं पूर्ण बनाती है, बशर्ते कि सहायक सामग्री का चुनाव बालकों की आवश्यकता एवं उनके मानसिक स्तर को ध्यान में रख कर किया गया हो। हमें यह भी ध्यान में रखना चाहिये कि जिस प्रकार "Too many cooks spoil the broth" इसी प्रकार आवश्यकता से अधिक सहायक सामग्री लाभ की अपेक्षा हानिकारक सिद्ध होगी।

—जगमोहन गर्ग

A Programme of Laboratory Centered Science Education

SCIENCE has played an outstanding role in our life in the recent years and is now changing our entire existence in such important aspects as health, transportation, communication and power. We are living in an Air-age, a Power age and an Atomic age. We all need to be familiar with applications and implications of Principles of Science to be able to live effectively in the New Technological world.

Educators have long recognised the advantages of first hand direct experience. This is exemplified particularly in Science where many of the concepts

as well as the techniques and devices are new to the beginners. These new concepts, terms, and principles are made meaningful by actual use.

Psychologists have determined, on the basis of their findings, that learning by doing has many advantages over mere reading about principles and subsequently developing concepts. Laboratory is the only place where one gets sufficient opportunity for getting first-hand experience. Many principles and concepts in science are quite abstract, for example, concept of Relative Density, Elasticity, Power force, Internal anatomy of frog etc. to the students of secondary classes. In most schools of today, I may say that 80% of High and Higher Secondary Schools, and 95% of Primary and Middle schools, the students have to learn important Laws and generalization by memorising them. These children will form vague concepts about the principles of science. A well planned Laboratory programme can make important principles and applications more meaningful for the children.

The distinguishing characteristics of all Laboratory programmes are that they are performed with apparatus and materials by an individual or a small group to find either qualitative or quantitative solution to the problem. The above statement holds good at High or Higher Secondary School level. Preparation of a gas, connecting bulbs in series or

Parallels, Dissection of Frog or Flower are some of the examples of qualitative type, while linear expansion, Resistance of cell or wire, Water of Crystallisation are the examples of quantitative. In order to make the Science Education Laboratory Centered, the following three hindrances generally come in the way :—

1. Space for the Science Laboratory.
2. Science Teacher with due qualifications.
3. Equipments or Materials.

The first and the foremost hindrance in carrying out the programme is the provision of a separate science laboratory. At the very outset this seems to be an administrative problem, but as a matter of fact this can be tackled at both ends. So far as the Teaching of Biology is concerned the entire Natural surroundings can be used as Laboratory. The Government is also providing additional rooms to be used as science laboratory. The Headmaster of the place can also seek public co-operation to solve the problem.

So far as second hindrance is concerned, I am of the opinion that the condition is far from satisfactory. In most of the Middle and Primary and few High schools non-science teachers are teaching science and as such however honest the teacher may be he cannot do justice to the subject. The present policy to give higher start to Science

Teacher will definitely improve the situation.

Let us examine the third hindrance. The value of providing sufficient quantity of equipment has long been realised and every year a large sum is kept apart for the purchase of equipment. This has brought the improvement at the secondary level, but the condition of Middle and Primary schools is very miserable. It is felt that suitable sums should be provided to purchase equipment of science at the primary and middle school levels. Moreover, in order to make science teaching a real laboratory centered there should be effective co-ordination between science, craft and drawing teachers, so that more and more improvised apparatus may come out from High and Higher Sec. Schools. The production of improvised apparatus will develop creativity amongst children and will provide materials to the lower classes for Experimentation. So far as Biological Museum is concerned I can say from my experience that the entire museum for high school level can be made locally. Such inexpensive equipment is found to be a more effective learning device than the commercially made equipment.

Steps to make Science teaching Laboratory Centered.

1. In the beginning of the school year the Science Teacher should divide the science syllabus into Laboratory Units. This will give him the idea as

to how he is going to give first-hand experiences to his children. Moreover this will make his teaching meaningful and interesting for the children.

2. So far as possible develop experiments in the course of class discussion. By this the saving of time in the Laboratory shall be considerable.

3. High School Laboratory work usually involves the carrying out of the experiments by individuals or by the small group of two or three. Frequently all students in the class work on the same experiment, mostly in Chemistry and Biology, but it is often desirable that more than one kind of experiment be undertaken by the different groups of students.

4. The students should be given full opportunity to participate with the teacher in planning the Laboratory Programme. This situation calls for initiative and resourcefulness on the part of the students. The usual laboratory situation with limited equipment stimulates the child to co-operate with the fellow students and handle the apparatus very carefully. This will have another advantage that the teacher and the students will make improvised apparatus.

5. Reporting of individual work may be in the form of oral questions or presented more formally in the classroom. Such a report gives a teacher greater insight as to what the students have accomplished. It is also possible

to explore details further, to investigate problems which have developed as the result of the work. This will also give sufficient evidence for evaluating the actual achievement of the students.

6. The laboratory report may consist of a short Test or quiz. The quiz may be planned to determine what knowledge and skills have been achieved for the fulfilment of certain desirable objectives.

In the end I will like to conclude that if science teaching is to be made more meaningful, and to develop creativity in the students, the entire science teaching has to be laboratory centered. Let this programme be filtered down to the Primary school level.

—G. S. Mathur.

Teaching of Science in Schools

Its Advantages and Some Practicable Suggestions

THERE is no denying the fact that to a very large extent science has created the world we live in today. The reason is obvious; it is through science that a host of new materials have been made available to us and it is science which has enriched some of the, progressive and the advanced countries of the world, removed ignorance, dispelled

superstitions and made them happy and prosperous.

These values of modern science were known to the late Shri Jawaharlal Nehru as he himself was a student of science and had been following with keenness and admiration the impact of scientific discoveries on life and living of people. Hence, ever since his appointment as the Prime Minister of Independent India he laid great stress on the teaching of science at all the stages of education, and also on scientific research in the universities, on well-equipped laboratories in several parts of the country, and on the fullest utilisation of the findings of the scientists by the Indian industrialists for the economic growth of India and the well-being of her people. The cherished plan of Shri Jawaharlal Nehru will be fully accomplished only when every individual in India imbibes the spirit of science, understands the basic scientific principles and is generally acquainted with the significance of scientific discoveries. This means that an outlook or an atmosphere has to be created which would make every person in India feel that he or she can no longer afford to ignore science, and to realize that his or her education is incomplete, if he or she has not received a good education in science.

A child begins the study of science from its early childhood, since it has the instinct of observing the behaviour

of things happening in his environments in everyday life, and also of drawing inferences from its observations. We have therefore to develop this natural faculty of children on right lines under proper guidance in an effective manner from their very childhood. In this context, the announcement of the Indian Minister of Education, Shri M. C. Chagla, that "the Government of India wants to introduce the teaching of science at the primary school level", is very welcome.

Obviously, it is being realised now more than ever before that the teaching of science should be given the highest priority in the system planned for the education of our children from their early childhood, both at homes and in schools. Possibly, the entire education of children of all ages could be remodelled and conducted with definite advantages through the medium of science. In the following lines some necessary and practicable suggestions have been made to make the teaching of science in schools effective and productive in all its aspects.

(a) The teaching and the syllabi:— In the schools, science is taught according to the syllabi drawn up by competent authorities specially constituted for this purpose. This is rather an intriguing matter both for the persons who have to frame the courses and for the pupils who have to go through it. Many times the teachers also experience

difficulties in teaching on account of the rigidity of the syllabi which they are obliged to follow slavishly and thereby get into a rut for the rest of their lives. Therefore, it is worth considering whether the policy of having well-defined syllabi is really good. The teachers who, on completing the given syllabus, get the feeling of satisfaction of having discharged their duty and the assigned responsibility, will like the detailed courses. However, there are others who would not like to follow the prescribed syllabi in exact details but to have the liberty of imparting the knowledge which their pupils in several standards are expected to acquire, under the given general guidance.

(b) Methods of teaching:—Several methods of teaching have been suggested and practised by educationists from time to time; these are still followed in one form or the other in many institutions in different countries. Science teachers in India may also follow any one of these methods or their suitable modifications or adopt a combination of several parts of different methods according to their likings. However, in every case they have to make sure that the pupils are profited by their teaching.

A really good teacher need not be bound by the technicalities of these methods, as he should be capable of inspiring his pupils to the desired extent and win their confidence, and when

this happens, he will be able to teach them everything by any methods he chooses.

The science teachers in schools should realize that the required knowledge can not be given to children by means of lectures only as it happens in colleges and universities; they have really to get into direct and intimate contact with them through lessons extensively demonstrated with well-designed experiments and interspersed with inspiring anecdotes about the scientific discoveries and the lives of their discoverers.

The science teachers should in no case dictate notes to their pupils on any topic dealt by them in the class; instead, the pupils should be asked to amplify the lessons they receive by referring to books recommended by the teachers. The written work of the pupils should be examined by the teachers and corrected. This practice will help the pupils in writing; this in turn will train them in the art of answering questions set at examinations in a proper manner with few or no mistakes, and thus enable them to gain valuable marks which they would otherwise lose. This practice will also help the teachers to know whether the lessons given by them have been correctly understood by the pupils or not, and to distinguish the really good pupils from those who either shirk work or are indifferent.

(c) Laboratory work :—Practical work is essential for teaching science, as it enables pupils to acquire knowledge which easily gets deep-seated in their minds. Hence it should form an integral part of the prescribed syllabi. It is well-known that children enjoy practical work and hence attend to it with enthusiasm.

To enforce practical work in all schools and in all classes, it will be necessary to hold regular examinations in practicals as otherwise they will be considered unnecessary and hence will be purposely neglected in most schools. This examination should be conducted in the whole practical course; selected experiments alone should not be set from year to year as this would lead to the negligence of other equally important ones.

The practical work will educate the children in discipline also, because the experiments set for them will have to be performed in strict accordance with the given instructions. This value of practical work will be realised only when the pupils get the facility of working singly; the prevailing practice of making the pupils to work in pairs is not healthy, although it means a saving in teaching hours and expenses. The practical work will also help the pupils to understand the value of working in a tidy manner and the importance of the use of just the required amount of materials neither more nor less, particu-

larly in their chemical experiments. This work will automatically lead to the training of pupils in the method of writing out the descriptions of the experiments which they perform with all the essential details in a clear and unambiguous language, of commenting relevantly on the results obtained, and of drawing justifiable conclusions from them; thus they get habituated to a mental attitude essentially needed for conducting research.

(d) **Science Library :** Every school should necessarily maintain a library which should contain books on general science, science books dealing with lessons given to the pupils in the class-room and the laboratory and a few books of higher standards on recently developing subjects or topics; the latter will inspire the intelligent and enthusiastic students to go for higher studies in science. The library should also subscribe to magazines on popular science with attractive printing and profusely illustrated pictures and diagrams. It will be a good practice for the teachers to talk to their pupils on the subject matter of the books loaned to them as this will enable them to know whether the pupils have actually read those books and have understood whatever they have read.

(e) **Extra curricular scientific activities :** These are really very good adjuncts to the knowledge given to the pupils in class-rooms and laboratories.

Further, they provide useful training to pupils in matters which can not be dealt in the class. Some of these important activities are mentioned below :

(i) **Visual aids :** Films are the most convenient forms of these aids because they are liked by the pupils on account of the amusement they give, and demonstrate in a clear, interesting and appealing manner complicated scientific processes which can not be shown and effectively explained in class-rooms. Educational films on varied topics are plentifully available at little cost, and should therefore be shown to pupils frequently outside the school hours. The only somewhat heavy expenditure involved in the provision of this facility is on the purchase of a projector and a screen which should not be denied. Film strips are really more efficacious than the films because the visual impressions get sufficient time for assimilation by the pupils. Television is also a very useful visual aid in science teaching, but its consideration has to be left out of account owing to the non-availability of this facility on the required scale in our country.

(ii) **Popular lectures :** These lectures should be arranged four to six times during an academic session. Pupils are sure to be attracted to them provided they are

given by eminent persons in an easily intelligible style in not too difficult language, and are illustrated by interesting experiments and lantern slides. Pupils will also look upon their contacts with these persons who are creating new knowledge or taking part in its advancement, as a matter of pride and pleasure, and will receive the desired inspiration from their associations.

(iii) **Scientific societies :** Scientific societies should be organised in every school and their meetings be held frequently. These meetings which will give opportunities to all pupils of the school to meet and know each other, should be very significant in solving the difficulties of juniors by their association with seniors. These societies will enable the pupils to learn by self-acquired experience the tact of running scientific organisations in an effective and efficient manner. Under the watchful eye of teachers, these societies may also be given the responsibilities of conducting the film shows and the popular lectures mentioned earlier. These societies should also organise trips to places of scientific interest and visits to industrial concerns; the pupils should avail these opportunities not only to see the applications of science in practice, but also utilise them to learn and understand the techni-

calities of business and their control. Once, at a convenient time of the year these societies should organise science exhibitions which should be thrown open to the citizens of the town. The exhibits should be designed, prepared and set by the pupils themselves in an impressive and artistic manner; they should also be trained to explain satisfactorily the scientific principles concerned with the exhibits to the lay public in non-technical language.

The suggestions made in this article for effectively introducing the teaching of science in schools are not mere airy nothings; they can be converted into realities by skilful teachers if they perseveringly devote the required time and attention to execute them. Admittedly, there is a deficiency of such teachers who are required in large numbers for millions of schools in existence in our country; the situation will be further aggravated by the introduction of science teaching in primary classes as well. The schemes of 'short courses', 'summer schools for school teachers', 'refresher courses' and other similar practices which have been introduced during the last few years to overcome the shortcomings of the science graduates, fresh and old, are commendable and deserve all encouragement. They will no doubt help to meet the demand of the talented and trained teachers with a reasonable time, and

will lead to the establishment of the desirable contacts between school teachers and eminent scientists working in universities, National laboratories, science departments of Government and industries. The authorities concerned with the management of schools should see that the emoluments paid to the teachers, who are pivots of the entire educational system, are adequate, so that they may not be obliged to spend their time and energy over other sources

of income, and are able to maintain their status and personality essentially needed to serve as ideals to their pupils. The science teachers will, in their turn, do well if they live a simple, sincere and devotional life; be affectionate, inspiring and true friends of pupils; and feel with Manu that "amongst all kinds of alms-giving or bounties, the imparting of knowledge is the greatest".

— Mata Prasad

GENERAL SCIENCE ITS POSITION IN THE SCHOOL CURRICULUM

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DULEY SINGH KOTHARI

GENERAL SCIENCE made its entry into the school curricula of the Indian schools some fifteen years ago and since then it has stayed there. Recently however, a controversy has arisen about the status and position of this subject in our school education. The controversy is apparently between the two schools with diversified views. According to one school of thought General Science should be allowed to continue as such in the traditional way. By this it is not to be implied—and if anybody does so he would be acting under a great misunderstanding and misconception—that the advocates of this view are in the least indifferent or opposed to the reforms directed to improve its contents and to present it in a more impressive and integrated manner incorporating the salient features worthy of its study. The second school of thought seems to have shaken all its faith in General Science as a subject, at least from the viewpoint of the school education. The supporters of the latter view feel the necessity of replacing General Science with more

Duley Singh Kothari ; General Science in School Curriculum

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formal disciplines in science such as Physics, Chemistry, Biology and Geology. They advocate the inclusion of these disciplines in suitable groups from the very beginning, say, sixth form or so. In U.S.A. and more particular in U.S.S.R. there is a growing tendency to resort to formal disciplines from the school stage.

Which of the two schools of thought is correct ? It may appear to be a simple problem but doubtlessly it has a "deceptive simplicity" about it. By no means we find it as simple as it might appear at the first sight. It might be argued that after a good deal of experimentation when the progressive countries like America and Soviet Union favour the study of formal studies, why do we not also recommend the same for our schools ? In one way it seems quite logical and convincing, but before we come to any conclusion we have also to weigh dispassionately the conditions which obtain in those countries inside and outside schools. A hasty decision may again put us in troubled waters. India is already experiencing tremendous difficulties with regard to its highly limited resources and it can hardly afford to start on any experiment (more so in the field of education) which touches widespread areas of massive scales and dimensions.

We pose at this stage the most impertinent question "Why do we want to teach science at all in schools at elementary levels ?" This question appears to us more fundamental even than the form and composition of the subject. We feel that its shape and scope could be determined with greater certainty when once we are clear about the objectives with which such a study is to be undertaken.

Without going into deeper analysis of the situation we set two broad-based objectives for the pursuit of the study of science in schools. They are : (a) To kindle imagination, stimulate interest and stir curiosity in our young children in the study of nature displaying itself in so many varied manifestations. The study would be planned so as to foster the spirit of inquiry and discovering which forms the backbone of all scientific advancement both in knowledge and progress in technological development. We shall call it as expository function.

(b) To prepare young children for more advanced studies in the various disciplines of science, which they are supposed to pursue when they go to higher forms in the colleges, grounds will be prepared so that the children may be able to follow advanced studies with ease and comfort. We call this as "factual function".

As it should be apparent one function cannot afford to ignore the other altogether; such an attempt would be completely suicidal and miserable. However, the question of laying proper emphasis on the first or the second objective will have

to be duly considered while planning the nature and the composition of the curricula. Now if we subscribe to the first objective as main, the study of science as General Science will certainly prove more useful and beneficial. However, the courses will have to be integrated, rewarding and related to daily life and needs of the society. Adequate stress will have to be laid on the Field study and Nature study. The text-books will have to be carefully prepared so that spirit of General Science course is properly maintained. Many books on General Science and science in daily life are available which could form excellent help books or guide books.

The teachers will have to be prepared, but a single teacher, we believe, shall be able to teach the subject, and only one Laboratory or class-cum-laboratory will do.

If we accept the second alternative as the aim of teaching science, we shall have to teach the subject in the form of formal disciplines with more emphasis on facts rather than on the ways these facts were discovered. Such an attempt would enable us to cover larger areas in relatively shorter durations.

These courses will be more ambitious and contain detail which might anticipate more serious study and even higher intellectual standards than the average.

It may not be quite advisable to entrust the different disciplines to a single teacher and even a single laboratory may not be very convenient. Of course here too the text-books will have to be prepared so as to be free from unwarranted factual and technological details and unnecessary mathematical intricacies. In teaching use will have to be made of specially designed demonstration materials and teaching aids.

Now we come to the query we raised in the beginning, which of the two objectives we are to pick up for teaching science in schools ? It is again a difficult issue to decide.

Considering the large percentage of the students giving up their education after passing middle class or secondary examinations, one could say that perhaps science taught in the form of General Science might be more useful in as much as the curiosity to know nature, which such a study will lead to, might stay till late in life. It might (in fact it should) encourage a taste for reading popular scientific literature which is so essential to understand, appreciate and interpret various situations one is likely to encounter in life. It might as well induce in students a taste to utilise their leisure in the pursuit of several useful hobbies such as making of interesting toys, models etc. Also if we believe that the aim of teaching science

to young children is not so much to impart knowledge as to create true scientific attitude and real spirit of inquiry, we prefer to think that a General Science course, carefully planned and projected, will be better.

It may be asked why then in America and U.S.S.R. the opinion is not in favour of General Science. In these countries, through the rapid scientific and technological advancement, science has entered every home and the boys and girls acquire much of the information that we plan to transmit to our children through regular and formal courses in General Science in class-rooms, by its impact on them. In the situations which obtain in the advanced countries, perhaps General Science course may not be so necessary as in India where conditions are rather so much different.

We wish to say that we should not be passionate in our reasoning. The issue demands a critical analysis of the problem in all its aspects, before a final decision in favour or against General Science course is taken. Before a final changeover to formal disciplines is made, it may be worth-while to give it a trial in some of the schools; there should not be any serious difficulty in running parallel courses. It might involve a little more expenditure or more exploitation of our resources, but in the interest of education at large, it has to be tolerated and sanctioned. If trial has meaning for us, we should try any new scheme before adopting it straightway once for all. Thereby we shall be acting cautiously (and also wisely) avoiding several of the pitfalls and hodgepodge.

Finally we should like to add that behind any scheme pertaining to teaching it is the teacher who is the most important factor to be considered. A good teacher is the primary requisite for any type of course. Let our hopes rest more on the teacher, his ability and capacity than on the syllabus that is put into his hands.

R. L. BHATIA

TEACHING SCIENCE IN ELEMENTARY SCHOOLS

SCIENCE has now been accepted as an important part of the curriculum for elementary schools, classes 1 to VIII.

The objectives for inclusion of Science as a subject at this stage are :—

- (1) Knowledge of environment as a part of the General Education of children.
- (2) Understanding of Scientific Principles by the children for solving problems in the environment.
- (3) Developing in children a scientific attitude.

R. L. Bhatia : Teaching Science in Elementary Schools

These objectives can be realised by making use of proper methods of teaching the subject, the methods which provide first-hand experiences to the children.

The most prevalent method of teaching science in our elementary schools is recitation from the text. Science is taught like a language. The teacher makes one of the pupils to read a passage from the text, after which he makes an oral explanation.

The corollary from this is that there is neither any demonstration by the teacher nor any observation or practical work done by the students. The learning of science consists in memorisation of principles or procedures, and there is no development of the skills of manipulation, experimentation, or of making sketches. As the students are not afforded any opportunity for making any observation or gaining any experience, the objectives of teaching science to them remain unfulfilled.

This faulty method of teaching science by recitation stems from two important factors—

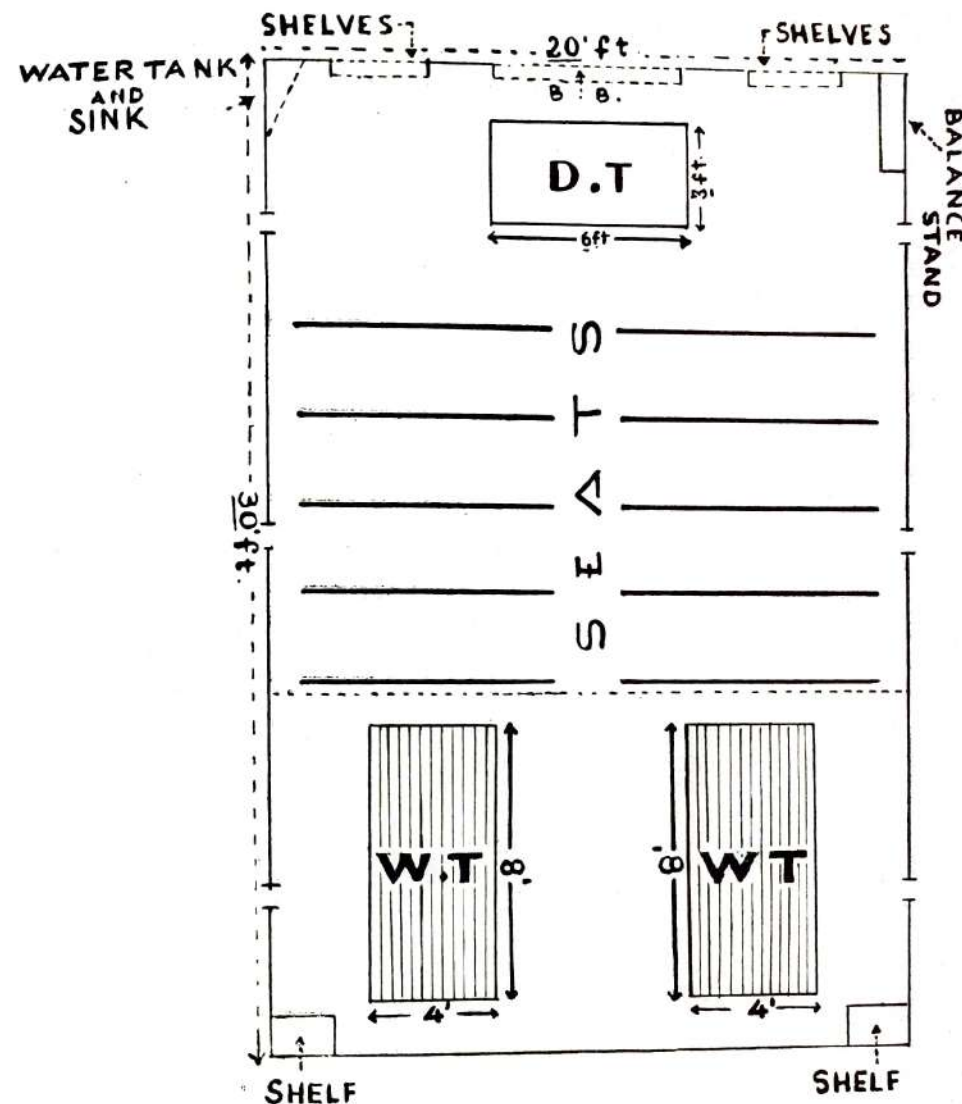
- (i) Incompetence of the teacher;
- (ii) Non-availability of equipment.

The teacher is far more important than the equipment but let us first consider the equipment.

Equipment

There is no need for having elaborate science equipment for elementary schools nor buying much of it from outside. Only the most essential articles like tools, glassware, etc., should be purchased. The elementary school science room should be a small workshop, fitted with work benches, tools, and shelves for simple apparatus and reagents.

Many other articles of use can be had from the local market or collected free of cost from home, school or community, e. g., empty tin cans, pans or plates, wooden and card-board boxes, empty glass bottles, rubber balloons and balls, nails, string, pins, knife, medicine dropper, iron and copper wire etc.



Methods of Teaching

The methods of teaching science must essentially be based on the performance of some activities, e. g. observation and practical work by the students, demonstration by the teacher, the designing and making of improvised apparatus, performing experiment with it and then arriving at conclusion, or generalisations. The activity is a part of the lesson itself.

Teacher Training

One of the main objectives of teacher training is to help the prospective teacher to acquire an adequate standard of professional efficiency in his work.

The professional efficiency and needs of a general science teacher are :

- (1) He must possess a definite and correct knowledge of the subject matter;
- (2) He ought to be efficient in handling equipment and performing simple experiments;
- (3) He should be able to improvise equipment;
- (4) He must be efficient at drawing correct, neat, bold and self-explanatory diagrams;
- (5) He should be able to guide the Junior Science Club activities and organise junior science exhibitions or fairs;
- (6) In his day to day teaching he should be a good demonstrator.

So the programme of training in general science at a basic S. T. C. School or a short-term training course, should consist of the following items of instruction:

- (1) Subject matter coupled with demonstration;
- (2) Performance of all the experiments occurring in the Texts from Class III to VIII;
- (3) Laboratory practice e. g. cutting, bending of glass tubes, fitting of apparatus, making dilute acid solutions, filtering, distilling etc.;
- (4) Making of improvised equipment;
- (5) Practice in drawing good diagrams;
- (6) Preparing simple charts and making of plaster models of insects and body organs;

(7) Collection and preservation of specimens;

(8) Organising science exhibition.

The correct knowledge of the subject matter, on the part of the teacher, is the first and the foremost professional proficiency. No method, howsoever good, will help, when the knowledge imparted is vague and ambiguous. It may be argued that the present syllabus does not provide for training in this respect, but it does, because training in the methods of teaching implies the correctness of knowledge.

It is, therefore, imperative that teaching of the subject matter should be included even in the existing scheme of training. This can effectively be achieved if the Science Instructor at the Training school devotes the first month of the training period to demonstrations on selected topics, with a view to teach the subject matter rather than emphasise the teaching method. At the elementary stage methods of teaching cannot be divorced from the content of teaching.

To develop familiarity with and handling of apparatus and skill in experimental work, there should be a well-equipped laboratory of high school standard in an STC School. The trainees should be made to perform all experiments occurring in the text-books from class III to VIII and have practice in simple laboratory work e.g. cutting and bending of glass tubes, fitting apparatus filtration, distillation, testing acids, alkalies etc.

Improvised Equipment

Making of improvised equipment should be an essential part of training in teaching of science. It is a useful and purposeful activity, because the equipment or an apparatus made is put to immediate use for an experiment.

This work will involve the application of skills of various elementary craft works, e. g. Wood-work, Card-board, Glass-cutting, Clay-modelling etc.

The Science Teachers and students should seek the help and guidance of the Craft Instructors of their school in designing and making their equipment.

The family craft resources of the students (e. g. students from carpenter, smith, agriculturist, potter, or technician families) must be tapped, developed and utilised in making improvised equipment and conducting Science-Club activities.

Collection

Collection of leaves, stems, roots, flowers, fruits of plants, insects, common reptiles, minerals, etc., has an important significance in teaching elementary science.

R. L. Bhatia ; *Teaching Science in Elementary Schools*

Students should be taken out for collection work, so that they may be familiar with the natural environment of plants, animals etc. The collections should be well preserved.

Science Exhibition

In every training course, full period or short-term, the trainees should be assigned and made to complete one or more projects in the form of improvised equipments, models, charts and collections. An exhibition of all these projects should be arranged towards the close of the training period. The exhibition gives an opportunity to the participants to know of the work done by one another. It is useful to the teachers, who did not participate in the training, and also to the students.

Every school must have a Science Club, where students may work out of regular school hours. The work of the Science Club should be exhibited in the school Science Fair or at the school annual day.

SUMMER INSTITUTES IN SCIENCE

A PLEASANT EXPERIENCE

GORDEN L. HIEBERT

ANYONE who has been involved with a summer science institute knows that the year divides cleanly into halves—the six weeks of the institute and the rest of the year. The six weeks is a time of re-awakening professional interests, of meeting colleagues from diverse places yet with common problems, time of mounting enthusiasms and deepening fellowship. It is a time of renewal. The rest of the year is merely that time that must be clocked away before another summer institute can be convened. Perhaps this is extreme view of someone who is overcommitted to the idea of summer institutes but even so, no discussion of science education can be complete without taking into account this powerful, new mechanism for upgrading the teaching of science.

During the summer of 1964 I had the privilege of being a consultant at the summer institute in chemistry held at the University of Rajasthan under the direction of professor Mehrotra. The opportunity to return to India and again work in the summer institute programme was seized with alacrity, and this past summer I had the very pleasant assignment of visiting twelve different chemistry institutes throughout the length and breadth of India. It is my pleasure to describe the programme.

Actually there are a number of different programmes of institutes : there are summer institutes for teachers from polytechnic and engineering colleges, summer institutes for college teachers of science and mathematics, and summer institutes in science and mathematics for teachers from secondary schools, preuniversity colleges, intermediate classes and training colleges. Most of my experience has been with the later type which in some ways is the original or parent variety.

G. L. Hiebert : Summer Institutes : A Pleasant Experience

The State of Rajasthan was the host to two institutes in 1964, with an institute for school teachers of mathematics at Mt. Abu under the direction of Dr U.N. Singh, in addition to the chemistry institute at Jaipur with which I was connected. In 1965 Rajasthan was the home of seven institutes. At the state university Prof. R.C. Mehrotra directed two chemistry institutes, one for school teachers and another for college teachers. An institute for college teachers of mathematics was convened at Udaipur by Dr S.P. Kaushik, another for school mathematics teachers at Jaipur by Shri K.N. Mehra. Jodhpur also was host to a school biology group directed by Prof. U.N. Chatterjee. School teachers of physics had a choice of institutes at Udaipur directed by Shri D.S. Kothari or at Ajmer directed by Dr D. C. Pandeya. It is not at all surprising that a number of these distinguished summer institute directors are among the contributors to this issue of *Naya Shikshak*.

Summer institutes started in the United States as a means of effecting a badly needed renewal and strengthening of science education in the schools. Communication between the college and the high school had virtually ceased, the esteem for the school teacher had fallen seriously and the community despaired of making any real improvement. Science was making great strides forward yet teachers continued to follow tradition bound courses. It was high time that a dialogue be established between college and university teachers on the one side and the school teachers on the other. Pious hoping was not enough; just writing articles about each other was not enough; nothing short of personal confrontation would do. Furthermore, they needed to talk directly without any intermediaries. The summer was the time when both parties could confront each other. The summer institute idea was the result.

In a summer institute selected school teachers of science are invited to study their subject under the direction of leading scientists and science teachers of a host institution. Between three and four dozen teachers take up residence in college dormitories and attend regular classes. They participate in prelaboratory discussions, perform experiments, and then in post-laboratory critiques analyze and correlate data. The institute provides an opportunity to review fundamental principles, and learn about recent developments. The teachers who participate not only learn from their mentors but from each other. Often the participants themselves conduct some of the discussions and exchange their own ideas for improving instruction in science. A summer institute is the meeting ground of the science teacher and the scientist.

Recognizing the logic of the summer institute format, the then newly organized National Science Foundation gave generous financial support to the undertaking. Summer institutes proved to be a very successful mechanism for bringing the scientist and teachers together; so successful that other varieties of institutes were devised. The academic year institute wherein a teacher was given a regular stipend for taking a year of training at some host institution was a natural outgrowth of the summer institute. The inservice institute in which a teacher continues his training and job simultaneously was an appropriate variation of the institute idea for urban areas. Sequential institutes which culminated in a masters degree were another variation.

Another line of National Science Foundation activity was to financially support the development of new curricular material. Leading scientists in each field accepted the challenge and organized task forces for the job. With great wisdom, outstanding science teachers were brought into the committees.

The marriage of modern science and good teaching was fruitful. The new text-books developed were not just a "rearrangement of the old with a few cautious deletions" but radically and profoundly new. Not only new text-books but an integrated set of laboratory experiments developed. An effort was made to use inexpensive and readily available materials. Where direct observation of an important phenomenon was not possible in the laboratory, filmed demonstrations were provided. A set of quizzes and examinations were part of the package. To help the teacher, who stands alone before his class and finally must rely on himself, a comprehensive guide and reference book was prepared. It distilled the wisdom of those master teachers who helped develop the material and others who helped field test it.

The result is what might fairly be called a new approach to science education, an approach which emphasizes concepts instead of facts, thinking instead of memory. Hopefully the student who takes the new course is being trained not just in the history of science but in the very method and technique of science. With these new materials even the isolated teacher with limited resources would have a chance to offer a first rate modern science course.

Each major discipline had its committees of scientists, scholars, and teachers. The School Mathematics Study Group (SMSG) developed the mathematics texts and commentaries. The physics course was developed by the Physical Science Study Committee (PSSC). The Chemical Education Material (CHEM) Study Group developed a course based on the principle that science begins in the laboratory.

Another group developed a modern chemistry course based on the Chemical Bond Approach (CBA), while the Biological Science Curriculum (BSCS) developed a course emphasizing ecology and evolution (The green version), another based on the cellular approach (the yellow version), and a third course (the blue version) that stresses the molecular basis of biology. Such was the harvest of new courses which both jointly and individually exemplify the new approach to science education.

The National Council of Educational Research and Training (NCERT) has undertaken the publication of an Indian edition of the science text-books, laboratory manuals, and teachers' guides and the Indian edition of the mathematics books is expected to come out soon.

Summer institutes became the agency for promulgating the acceptance of the new approach. Teachers who had been given small enough rewards for many years, were now expected to retool. Of course they needed help. Given a chance to relearn their science and mathematics they were equal to the task. Obstinacy gave way to enthusiasm and summer institutes flourished.

India and America have many characteristics in common. We share an interest in science and renewing and upgrading science education. Thus, it is not surprising that summer institutes which have flourished in America should take root in India. The scene is different but the problems are the same.

From four seeds sown in 1963—one institute in mathematics, one in physics, one in chemistry, and one in biology—a crop of forty-four institutes in 1964 resulted. This yield included sixteen institutes which used the new curricular materials developed by the National Science Foundation, an additional twenty designed for college teachers, four more for teachers from engineering colleges, and another four for teachers of polytechnic colleges.

The 1965 harvest of summer institutes grew to ninety-four with forty-seven for school teachers, thirty-one for college teachers, and eight each for the engineering and polytechnic college teachers. Plans for another bumper crop of institutes in 1966 are underway.

Now summer institutes are expected to be an agency of renewing science education, but given the usual structures that govern the class-room teacher it is not fair to expect that single institute experience will do the whole job of bringing about all the developments that are desired. Therefore, the joint planners of the summer institutes are working on plans for appropriate "institute alumni functions." Teachers who do have an opportunity for carrying out some educational experiments will need additional help and encouragement. Indian task forces of scientists and

teachers will have to be organized to bring out new course material best suited to the local scene. A programme of assisting the production of new text-books, laboratory materials, inexpensive scientific instruments for class-room use, teaching films and charts and other paraphernalia of the modern science class-room will have to be designed and produced indigenously. This phase of follow-up activity is also on the drawing board and part of the plan for next year.

Who are the authors of all these programmes? The summer institutes have been joint undertaking of the Indian and American academic communities. The National Council of Education Research and Training and the University Grants Commission together with the Education Division of the United States Agency for International Development have been the Official partners. The working partners of the school level institute have included the Director, four or five staff members, an American college professor, and an American high school science teacher. Working together, they have designed and carried out the institute programme. The forty-plus participants in each institute have been important members of this partnership.

For the follow-up phase of the summer institute programme it is hoped to expand this partnership. Scientists and educators will have to be released from their regular work to take up this important job. Writers and artists, designers of instrument and laboratory apparatus, experts in the use of audiovisual teaching devices, publishers and manufacturers will have to be marshalled to the task. Finally the whole academic community must respond if the job is to be done well.

The summer science institute, more particularly the summer institute along with a follow-up programme, is a proved technique for renewing science education. For me it has been a privilege to work in summer institutes both in America and India. I am confident that as more teachers attend these institutes and the necessary follow-up is made the renewal of science education is assured.

BACKGROUND AND ACHIEVEMENT

M. L. MEHTA

THE KNOWLEDGE-BASED WORLD is no longer a place of slow and gradual change. Teaching of science cannot be effective unless it is animated by an awareness of the rapidly extending boundaries of scientific knowledge. Equipment and books alone, however good they may be, will not avail much, if the teacher does not have adequate mastery of the subject. The Summer Institute's programme is intended to provide facilities to teachers to acquaint themselves with recent developments in their respective fields of knowledge and modern curricula and techniques of instruction. This is sought to be achieved by bringing together, groups of science teachers—teachers from universities and teachers from schools working together—for a period of about 6 to 8 weeks during the summer vacation and by making available to them modern text-books, improved laboratory techniques and teaching aids, under the supervision of competent directing staff. The programme is jointly sponsored by National Council of Educational Research and Training, University Grants Commission and the United States Agency for International Development. The Summer Institutes bring the school and university teachers in a common endeavour to improve the quality and standards of science education.

The objectives of the programme are :

- (a) to establish channels of communication between schools and universities;
- (b) to improve the subject-matter competence of participating teachers by acquainting them with recent developments in their subjects;
- (c) to enable teachers to develop a better understanding of the basic concepts in their fields of specialization;
- (d) to enable teachers to conduct experiments, wherever possible with simple and improvised apparatus, and to encourage further experimentation along suggested lines leading to a consideration of theoretical ideas growing from experiments;
- (e) to strengthen the capacity of the teachers for motivating able students to develop an aptitude for research;

- (f) to stimulate interest in teachers by bringing them into contact with eminent men in the field of their study; and
- (g) to enable teachers to exchange views with their colleagues in the profession and thus promote a greater understanding and appreciation of each other's teaching problems.

In June-July 1963 four summer institutes for secondary school teachers, one each in physics, chemistry, biology and mathematics, were organized as a pilot project at the Universities of Delhi, Madras and Poona. These institutes were organized under the guidance of Indian directors in collaboration with the U.S. consultants. The services of American Experts were obtained through the U.S. National Science Foundation. Over 150 teachers of secondary schools out of nearly 800 applicants from all over the country, participated in the programme, and had the benefit of examining and studying new approaches to science teaching and text-books and teaching aids developed in the U.S.A. Thirty-two American Scientists attended these institutes as members of the staff.

The participants at these summer institutes have made an extensive use of the new curricular materials developed in the United States with the co-operative effort of university professors, top scientists and science teachers, e.g. 'new Mathematics' of the School Mathematics Study Group (MSG), of the package programmes of the Physical Science Study Committee (PSSC), of the Biological Sciences Curriculum Study (BSCS) and of the Chemistry Materials Study Committee (CHEMS STUDY).

Encouraged by the enthusiastic response of the participating teachers, it was decided to increase the number of institutes to 16 during 1964. These institutes were organized during June-July 1964 in collaboration with as many universities.

About 640 teachers selected out of nearly 800 applicants participated in the summer institutes.

High/Higher Secondary School teachers	578
Lecturers P.U.C./Inter colleges	40
Lecturers, Training Colleges and Regional Colleges	22
Total:	640

In April-July 1965 again, forty-nine summer institutes for secondary school teachers were organised all over the country in collaboration with the various universities. Nearly 2,000 secondary school teachers participated in the institutes.

88 American Experts were associated with these institutes as members of the academic staff.

The over-all position of the summer institutes held during the last three years is given below :—

Subject	Year			Total
	1963	1964	1965	
Biology	1	4	7	12 (500)*
Chemistry	1	4	13	18 (700)
Mathematics	1	4	16	21 (800)
Physics	1	4	13	18 (700)

	Biology	Chemistry	Mathematics	Physics
Total number of teachers in the subjects as in 1965	16,000	10,000	25,000	10,000
Percentage of Institute-trained teachers as in August 1955	3.1	7.00	3.2	7.00

Thus by August 1955, nearly 2,700 secondary school teachers i.e. about 5% of the total teachers' strength of the country were institutes-trained teachers ready to establish in their own class-rooms and laboratories the "new approach" to the teaching of their discipline. It would be ideal if all teachers of the secondary schools could have the benefit of institute-training, but this perhaps may not be feasible at present. A regular assessment of the working of the programme has been made by the sponsoring agencies through evaluation conferences. Both, teachers and administrators, are of the view that the summer institutes are making a positive contribution to the upgrading of standards of instruction. The sponsoring agencies are planning expansion of the programme every year. A suitable follow-up programme is also being worked out by these agencies, as without it, the programme may not have the desired impact. This would not be an easy task to accomplish but if all concerned work assiduously to institute the follow-up programme, by the end of the 4th Plan nearly 30 to 40% of the science students of the country would learn the "new science" by newer methods of approach.

*Figures indicated in brackets show the approximate number of institute-trained teachers.

राजस्थान राज्य का विज्ञान शिक्षा-संस्थान

यह संस्थान उदयपुर में है। संस्थान के चारों तरफ अरावली पर्वत की सुरम्य श्रेणियाँ हैं। प्रकृति ने स्वयं विस्तृत भौलों, घने जंगलों एवं आकर्षक उद्यानों के परिवेश में उदयपुर को निश्चित ही इस संस्थान के अनुकूल वातावरण दिया है। राष्ट्रीय शिक्षा अनुसंधान व प्रशिक्षण परिषद् (NCERT) की योजनानुसार ऐसे संस्थान भारत के प्रत्येक राज्य में खुलेंगे। नौ राज्यों में खुल गये हैं और आशा है शेष राज्य भी अल्पकाल में ही इस योजना को क्रियान्वित करेंगे।

"इन संस्थानों की स्थापना के पीछे कौन से प्रेरणा-स्रोत हैं?" यह प्रश्न स्वाभाविक है और कोई भी कर सकता है। वास्तव में यह एक बुनियादी प्रश्न है और इसका उत्तर भी इस तथ्य में निहित है कि विज्ञान एवं प्राविधिक क्षेत्रों की आशातीत प्रगति होने पर भी हमारी विज्ञान शिक्षा द्रुतगामी विकास के साथ सभी स्तरों पर कदम रखने में समर्थ नहीं हो पायी है। नये ज्ञान को और ज्ञान पाने की नई पद्धतियों को हमें हमारे स्कूलों में भी निरंतर लाते रहना है। अमेरिका, रूस, इंग्लैंड आदि कई देशों ने बहुत से कार्यक्रमों एवं प्रोजेक्टों के माध्यम से उन शास्त्रीय एवं परम्परागत अध्यापन प्रणालियों में आमूलचूल परिवर्तन लाने में प्रगति की है जो मौलिक विचारों की अपेक्षा तथ्यों पर अधिक जोर देती थीं। इस दिशा में अमेरिका की भौतिक विज्ञान अध्ययन समिति द्वारा तैयार किया गया भौतिक शास्त्र का कार्यक्रम एक अद्वितीय कदम है।

भारत की स्थिति इस दिशा में अभी पूर्णतया मिला है। हमारे पाठ्यक्रम अभी भी परम्परागत हैं। हमारी पाठ्य-पुस्तकें गिनती एवं तकनीकी विवरणों पर ही जोर देती हैं और उनमें ढेर सारी व्यर्थ की पुरानी बातें भरी हैं। हमारे अधिकांश अध्यापकों ने भी समय के साथ बढ़ने की ज़रूरत को अभी नहीं समझा है। भारतीय शिक्षा मंत्रालय, विश्वविद्यालय अनुदान आयोग, राष्ट्रीय परिषद् आदि संस्थायें भी शिक्षा की असन्तोषजनक स्थिति से चिंतित हैं। विज्ञान शिक्षा की प्रगति के लिये यह उचित समझा गया कि प्रत्येक राज्य में एक विज्ञान संस्थान कायम किया जाय। निस्संदेह यह एक

जबदस्त चुनौती का कार्य है। इस महान् कार्य की सफलता इस कार्य को चलाने वालों की सूझबूझ, अथक प्रयत्न एवं आगे होकर कार्य करने की योग्यता पर निर्भर करती है परन्तु बहुत कुछ सफलता इस बात पर भी निर्भर करती है कि विश्वविद्यालयों, कॉलेजों एवं शैक्षणिक संस्थाओं का इन संस्थानों को कितना सहयोग मिलता है।

उद्देश्य :-कई उद्देश्यों में से कुछ निम्नलिखित हैं :-

- १ - विज्ञान शिक्षण के वर्तमान स्तरों में परिवर्तन एवं सुधार लाना;
- २ - वैज्ञानिक मूल्यों को अधिक अच्छा समझने के लिये कार्य करना एवं अधुनातन विज्ञान की जानकारी देकर जीवन में इसके महत्व को और अधिक समझना;
- ३ - विज्ञान-शिक्षा के विस्तार को गतिशील बनाना और दिनोदिन ऐसे क्षेत्रों में प्रवेश करना जो आजतक सामने न आ पाये हों और जिस पर किसी ने ध्यान नहीं दिया हो;
- ४ - विश्वविद्यालय व कॉलेजों के प्राध्यापकों व स्कूलों के अध्यापकों के बीच की वर्तमान खाई को दोनों के सहयोग से पाटना;
- ५ - स्कूलों में विज्ञान शिक्षा की वर्तमान स्थिति का सर्वेक्षण करना;
- ६ - विज्ञान में रुचि पैदा करने वाले सभी प्रकार के कार्यक्रमों या प्रोजेक्टों को प्रोत्साहन देना;
- ७ - विज्ञान में रुचि रखने वाले प्रखर वृद्धि वालकों को ढूँढ़ना एवं उन्हें आगे के अध्यापन के लिये साधन एवं प्रेरणा प्रदान करना;
- ८ - विज्ञान अध्यापकों से निकट सम्पर्क स्थापित कर उनकी छोटी बड़ी सभी समस्याओं को समझने का प्रयत्न करना;
- ९ - विज्ञान शिक्षा से संबंधित शोध एवं अन्वेषण के विभिन्न क्षेत्रों में गवेषणा हेतु विविध योजनायें बनाना;
- १० - "कहके सीखने" की अपेक्षा "करके सीखने" की आवश्यकता पर बल देना।

संस्थानों में इन उद्देश्यों की पूर्ति के लिये राष्ट्रीय परिषद् सभी के लिये समान प्रवृत्तियों का एक सिलसिला ढूँढ़ने का प्रयत्न कर रही है। स्थानीय आवश्यकताओं व साधनों के अनुरूप परिवर्तन कर इन प्रवृत्तियों को अपनाने में ये संस्थान स्वतंत्र होंगे। उदयपुर संस्थान में जो प्रवृत्तियाँ अभी चल रही हैं वे निम्न हैं :-

१. माध्यमिक शालाओं के लिये सामान्य विज्ञान एवं गणित के ग्रीष्म विद्यालय (समर स्कूल) - माध्यमिक शालाओं में सामान्य विज्ञान एवं गणित के अध्यापन की जो दयनीय दशा वर्तमान में चल रही है राजस्थान सरकार का शिक्षा विभाग उससे भली भाँति परिचित है। इसमें सुधार लाने के लिये लगभग पचास हजार शिक्षकों को नई जानकारी देना या नई शिक्षण प्रणालियों से परिचित करा देना आसान काम नहीं है। पर आसान हो या कठिन, विभाग इस कार्य को करने के लिये कृतसंकल्प है।

ऐसा प्रस्ताव है कि प्रति वर्ष २५ ग्रीष्म विद्यालय (समर स्कूल) चलाये जावें जो हर वर्ष ५ सप्ताह के लिये लगा करें और लगते रहें। इन विद्यालयों के संचालन के लिये उपर्युक्त व्यक्तियों को प्रशिक्षण देने हेतु संस्थान ने दो संगोष्ठियाँ आयोजित की थीं।

(क) प्रयोगात्मक पाइलट प्रोजेक्ट - उपलब्ध मामूली साज-सामान की सहायता से भी शिक्षक व विद्यार्थी कोई मौलिक महत्व का कार्य कर सकें इस दृष्टि से इस संस्थान से समय-समय पर कुछ प्रयोगात्मक प्रोजेक्ट विद्यालयों को भेजे जाते हैं। अब तक तीस विद्यालय इन प्रोजेक्टों को प्रारंभ कर चुके हैं। आशा है यह कार्य और तेजी से चलेगा।

(ख) विज्ञान अध्ययन केन्द्र - कालेजों, विश्वविद्यालयों एवं शिक्षकों को एक मंच पर लाकर ज्ञान व अनुभव के आदान-प्रदान, विचार-विमर्श तथा विज्ञान संबंधी विषयों पर आदर्शपाठ और चल-चित्र प्रदर्शन आदि प्रवृत्तियों के आयोजन हेतु इस केन्द्र की स्थापना की गई है।

अगले पाँच वर्षों के लिये प्रस्तावित कार्यक्रम निम्नानुसार है :-

१. पुनश्चर्या पाठ्यक्रम - (रिफ्रेशर कोर्स) ज्ञान के तेज विकास के कारण यह अत्यावश्यक हो जाता है कि हमारे अध्यापकों एवं शिक्षाविदों को अधुनातन ज्ञान रहे। इसके लिये पुनश्चर्या पाठ्यक्रम आयोजित किये जा सकते हैं।

२. कार्यक्रम का अग्रिम आयोजन - इस कार्यक्रम के अन्तर्गत विशेष रूप से स्नातक अध्यापकों के प्रशिक्षण की व्यवस्था की जायगी जहाँ वे गहन एवं क्रमिक ज्ञान ४० सप्ताह की अवधि में ही ग्रहण कर सकें और उन्हें हायर सैकण्ड्री कक्षाओं को पढ़ाने के योग्य बनाया जा सके। ये कार्यक्रम विभिन्न विषयों पर अलग से रखे जावेंगे और यह प्रयत्न किया जायगा कि भारतीय विश्वविद्यालय के बी. ए. ऑनर्स के स्तर को प्राप्त किया जा सके। शिक्षा विभाग से अनुरोध किया जायगा कि तरक्की एवं वेतन शृंखला में इन कार्यक्रमों को मान्यता दें। एक तरफ विज्ञान अध्यापकों की इससे कमी पूर्ति हो सकेगी, दूसरी तरफ अध्यापकों को अपना स्तर एवं भविष्य बनाने का सुअवसर प्राप्त हो सकेगा। कुछ समय के लिये इस कार्यक्रम को भौतिक शास्त्र एवं रसायन शास्त्र तक सीमित रखा जायगा।

३. आदर्श पाठ योजना - बुनियादी तौर पर वैज्ञानिक विषयों पर आधारित पाठों पर की गई अच्छी पाठ-योजनाओं को विभिन्न स्थानों में भेजा जावेगा। ये पाठ विषयवस्तु को इस ढंग से प्रस्तुत करेंगे कि आसानी से समझ में आजाय। संबंधित अध्यापकों से प्राप्त हुई आलोचना के आधार पर इनका स्वरूप निखरता रहेगा और अन्त में वे उपयोगी सामग्री के अंग बन जायेंगे।

४. कार्यशिविर (वर्कशॉप) - यह अत्यधिक महत्वपूर्ण है कि अध्यापक अपने वातावरण का ज्यादा से ज्यादा लाभ उठा सकें और नवीन प्रयोगों के लिये काम में आने वाले साज-सामान एवं यंत्रों का निर्माण कर सकें। यह तभी संभव है जब कि हमारे अध्यापक यान्त्रिक कार्यों में काम

आने वाले साधारण औजारों एवं उनके उपयोग में पूर्ण प्रशिक्षित हों। अल्पकालीन पाठ्यचर्यायें (शार्ट टर्म कोर्स) कार्यशिविर के अभ्यास के लिये बड़ी उपयोगी होंगी।

५. **पाठ्यक्रम एवं पाठ्यपुस्तकों का विकास** - अध्ययनार्थ उपयुक्त कोर्सों को स्थानीय परिस्थितियों को ध्यान में रखकर विकसित करना है। इस कार्य के लिये अलग से ही एक शाखा की स्थापना की आवश्यकता है। विभिन्न क्षेत्रों में विशेषज्ञों का सक्रिय सहयोग लेने का यह शाखा प्रयत्न करेगी। विशेषज्ञों के प्रत्येक दल में कम से कम तीन सदस्य ऐसे होंगे जो विश्वविद्यालय, कॉलेज अथवा स्कूलों के प्रतिनिधि होंगे।

६. **विज्ञान का प्रचार एवं प्रसार** - इसके लिये निम्न कदम उठाये जा सकते हैं :—

- (१) मौलिक साहित्य का सृजन।
- (२) विदेशी भाषा में उच्च-स्तर की पुस्तकों एवं विभिन्न रोचक लेखों आदि का अनुवाद।
- (३) छात्रोपयोगी सामग्री वाली एक पत्रिका का प्रकाशन।
- (४) एक प्रश्नोत्तर मंच की स्थापना।

७. **चलता-फिरता यूनिट** - इस संस्थान की उपयोगिता देहाती क्षेत्रों में स्थित स्कूलों एवं संस्थानों पर आसानी से नहीं पहुँच पायेगी। इस कारण एक ऐसे चलते-फिरते यूनिट की स्थापना किये जाने की योजना है जो समय-समय पर विभिन्न स्कूलों को देखती रहे और उपर्युक्त प्रदर्शन के साथ-साथ उनकी आवश्यकताओं की पूर्ति करती रहे। यूनिट पुस्तकालय, कर्मशाला एवं प्रयोगशाला सुविधाओं के साथ भ्रमण करेगी जिससे कि विज्ञान विस्तार शीघ्रता से हो सके। दृश्य-श्रव्य कार्यक्रमों की भी इसमें सुविधायें होंगी। यह यूनिट विज्ञान क्लब, मेले, प्रदर्शनी और अन्य इसी प्रकार की प्रवृत्तियों का आयोजन करती रहेगी जिससे प्रतिभावान विद्यार्थियों को प्रोत्साहन मिलता रहेगा और वे वैज्ञानिक कार्यों में रुचि ले सकेंगे।

८. **मूल्यांकन एवं निरीक्षण** - अध्यापन का उचित एवं सही मूल्यांकन करने हेतु, विभिन्न स्थानों पर यूनिट के प्रबन्ध एवं मार्गदर्शन में जाँच परीक्षाएँ रखी जावेंगी। विशेष उद्देश्यों को ध्यान में रखते हुए इन जाँच परीक्षाओं का निर्माण किया जायेगा।

९. **प्रसार कार्यक्रम** - वैज्ञानिक ज्ञान प्रदान करने और इसकी वृद्धि करने की प्रेरणा स्वरूप यूनिट जब-जब भी आवश्यकता समझेगी सेमिनार, अनुसंधानात्मक प्रोजेक्ट, विशिष्ट उद्देश्यों की पूर्ति हेतु विशिष्ट कोर्स, कार्यशिविर आदि का आयोजन करेगी। जैसाकि उल्लेख किया गया है प्रसार शाखा इन कार्यक्रमों का प्रबन्ध करेगी वह भी इस यूनिट के प्रधान अंग के रूप में कार्य करेगी।

जैसे जैसे संस्थान का विकास होता जायेगा वैसे वैसे इसमें अधिकाधिक नवीनता आती जायेगी और अन्वेषण के क्षेत्र भी बढ़ते चले जायेंगे। आमदनी के स्रोत सीमित होने के कारण सभी कार्यक्रमों को एक साथ क्रियान्वित करना संभव न हो सकेगा, फिर भी सावधानी पूर्ण योजना बनाई जावेगी।

-दु० सि० को०

TEACHER AND THE KNOWLEDGE-CONTENT

IN THIS ARTICLE, brief and sketchy, we propose to say a few words on the importance of subject-knowledge for a teacher, if he is to do his task with courage, confidence and competence. However, we should make it clear that ideas expressed here are based on our personal experience as a teacher and it would be no surprise if any of the readers don't agree with us wholly or partially.

Let us pause and ask ourselves :

1. What should be the scope of the subject-knowledge ?
2. What is its role from the point of view of teaching ?
3. What measures need be taken to improve it ?

I hasten to proceed.

(a) Scope of the subject-knowledge :

In our country, as the system goes, each class has a set and a prescribed list of topics in the various subjects to be taught. This list is drawn out by a body constituted by a Board or a Department of Education or by a University to which the teacher concerned is seldom a party. Be that as it may, the teacher is expected to cover all the topics and areas contained in the list in the limited time at his disposal. It is, therefore, of paramount importance that the teacher has a thorough understanding and study of all the topics. But merely the limited familiarity with the prescribed course of study may not be adequate. The knowledge of the teacher should be wider and deeper. It should not remain confined to the narrow precincts and the boundaries of the set syllabus, but should permeate into the regions extending quite far into the outer skirts. He should also be alive to the latest trends and traits in the subject. By himself he may not be an active researcher, but he should be able to appreciate the major problems and fields of inquiry and investigation, engaging the top persons and specialists. He cannot shut his eyes to the new vistas of knowledge that are opening up with bewildering rapidity. Nothing could be more dangerous than a teacher who rather likes to ramble into the already known stockpile of ideas and characteristically refuses to look ahead and peep into the new secrets and new mysteries of the knowledge. To take an example

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suppose there is the topic "Atomic Structure" in the list recommended. It is obvious that the knowledge of the teacher concerned should not be limited to the basic features of the built of an atom, but he should know how the present knowledge has accumulated, grown and developed, how one step led to another step, one discovery paved way for another discovery, one refinement resulted into another refinement and he should also understand the atomic riddles and intricacies which are engaging the attention of the scientists to comprehend the ultimate secrets of nature. A teacher is, of course, responsible to the syllabus but his responsibilities extend far and wide. The position of a teacher is like a guide leading a team to its destination. Just as a good guide not only knows the actual route to the place of destination but also has a complete information of all the places of interest on the way, likewise a good teacher not only understands prescribed course but also has a full appreciation of the important related fields and areas.

Besides his own subject, he should also find time to become familiar with the salient features of the allied disciplines. A physics teacher, for instance, will do well to acquaint himself with at least first courses of other Physical Sciences, such as Astronomy, meteorology (the science of weather), the earth's surface (land and water), Chemistry etc. A little familiarity with the rudiments of Biological sciences is also highly desirable. This will help him immensely to appreciate the more general and wider implications of the different physical concepts and also to seek better interpretation of the various situations confronted in daily life. To-day no subject develops or grows within its own confines as a watertight compartment, but threatens to probe into areas which at one time were considered to be quite alien and so the restricted study of one subject alone will result into piece-meal knowledge, quite detached and unrelated. It would simply lead to produce a disintegrated picture. An elementary knowledge 'to say the least' of allied subjects is as essential for a teacher as his knowledge in the subject of his main concern.

(b) Importance of knowledge-content :

An efficient teacher is by all means the greatest need of the hour. We affirm that much of the lowering of standards resulting in the huge and colossal "student wastage", noticeable at various stages in our education, is not so much due to lack of accommodation or want of proper facilities as due to inadequate teacher. When I say this I do not mean that we should blame teacher or penalise him for his inadequacy, because nothing good can ever result by acting in that manner; on the other hand it might create misunderstandings and heartburnings. All the same I wish to emphasise that when we are on the threshold of evolving a new pattern and

improving the existing one to suit our national needs, we should do well to focus attention to the improving of the quality of the teacher. And I hasten to say almost in one breath that the essential criterion of a good teacher, besides his character, is his knowledge. We do realise and admit that the pedagogic training dealing with the art and the techniques of teaching in conformity with the principles and psychology of Education, are in no way less important, but we do believe that only a teacher with up-to-date knowledge in his subject, will be able to put the training in Education to any material use, because such a teacher alone feels strong and firm (and shaky) and is inspired to practise new methods and adjust his teaching according to the aptitudes of his students. However we should like to think that a teacher with all pedagogic training but without adequate knowledge in his subject, will at best, be acting like a juggler who could only impress his audience temporarily by his manipulations and manoeuvrings with the result that everybody at the end feels that it was after all a mere show and nothing serious or real.

Essential and requisite quantum of knowledge brings several virtues to the teacher. They help in :

- (a) imparting confidence to the teacher, enabling him to meet his challenge with fortitude;
- (b) stimulating interest and kindling imagination in the students;
- (c) achieving co-ordination with allied disciplines and relating teaching to life;
- (d) exploring new avenues and vistas of investigation, so essential for better appreciation and understanding;
- (e) interpreting knowledge as a means of potential probe into wider areas and new fields of applications;
- (f) guiding students, like an expert navigator, to put the library to the best use;
- (g) devising and setting up interesting and thought provoking demonstrations using improvised materials;
- (h) keeping him alert so as not to become stale and stagnant.

All these points could be elaborated, but we are afraid the space at our disposal may not warrant such an attempt. We should only like to add that increasing knowledge and deeper familiarity with the subject will bring not only "freshness" to the teacher but will also impart much needed dynamism to his personality.

We now finally come to the last question. What measures do we have to suggest to keep teacher abreast with the fast rapidity with which new knowledge is pouring in everyday. Here are some of them.

(a) Refresher courses

Short-term courses or seminars extending over a period of 8 to 12 weeks must be instituted in the various subjects. In order that the course may be effective they have to be well planned and run by the experts drawn, so far as possible, from the Colleges and the Universities. Active collaboration of School teachers and University teachers working jointly in these and similar programmes will no doubt be a great innovation. We emphasise the necessity of providing the requisite library, laboratory and demonstration facilities. Arrangements must also be made for a modest workshop. Long-term advanced courses may also prove very useful.

(b) Summer Institutes

It is gratifying to note that the University Grants Commission, of late, has been sponsoring summer institutes in mathematics, Physical and Biological Sciences, to bring about a desired upheaval in our Science education, at all levels. These summer institutes are run in the various university departments with collaboration of the American Professors and teachers. One significant feature of these institutes is that they have almost a set programme, which includes lecture—demonstrations, laboratory work and films. The Summer Institute programmes are directed to acquaint teachers with recent developments in their respective fields of knowledge and modern curricula with new approach and deeper insight. They are meant to keep teachers abreast of the latest advances and to improve their professional competence. In U. S. A. Summer Institutes have almost revolutionised the School education. In our country, as well, they have bright future. However, they need implicit faith, devotion and dedication on our part.

It is necessary that Summer Institute programmes receive greater encouragement as a step towards improving the quality of teachers. It has to be interpreted as a continuous process through a well organised follow-up programme to have the desired effects in quickest time.

(c) Study circles

In U.S.S.R. the so-called study circles form the potential organ of the educational system prevalent there. Under these study circles, the science teachers and all others interested, meet periodically (twice a month) to attend lecture-demonstrations, and popular talks on topics of scientific interest, usually followed

by lively discussions in which both teachers and students participate. The programmes are initiated by the specialists from the Universities or by the teachers of experience and standing.

We believe that similar study circles could profitably be set up in India also, particularly at all those places where the required facilities are available. Apart from arranging interesting lectures on current topics, programmes on specified topics with illustrations and demonstrations, experiments designed to elucidate the fundamental concepts, might form the lively part of activities.

In conclusion we repeat again that the teacher of the right calibre and proper vision is the supreme need of the hour. We quote from the "Introduction to Summer Institutes"—published by the University Grants Commission, New Delhi :

"Equipment and books alone, however good they may be, will not avail much, if the teacher does not have adequate mastery of the subject."

The task of preparing teachers is the most challenging one and in this Universities, Colleges (including Teachers Colleges), academic institutions, schools and the administration have a very important role to play.

L. S. KOTHARI

NUCLEAR ENERGY

THE first public announcement of the fact that man had discovered a hitherto untapped and very powerful source of energy, was unfortunately made in very tragic circumstances. On August 6, 1945, the U. S. A. demonstrated the possibility of using nuclear energy in warfare by dropping a nuclear bomb (in common parlance called the atomic bomb) on the Japanese city of Hiroshima. This one bomb in which the explosive material was only about 50 kg. was equal in explosive energy to nearly 20,000 tons of chemical explosive like TNT. Since then the U. S. A., U.S.S.R. and U. K. have tested hydrogen bombs, which in explosive energy represent a thousand-fold increase over the earlier nuclear bombs. The energy released in the first test explosion of a hydrogen bomb in March 1952, was larger than all the explosive energy released in war up to then by man in his entire history. This tremendous difference between the energies released in the nuclear and chemical explosive is due to the fact that the sources of energy in the two cases are fundamentally different.

In a number of countries, a lot of effort is being directed at producing electrical energy from this new source and in a few decades a good fraction of the total energy consumed by any nation may come from this source. Apart from some thirty power stations that are presently working in different countries of the world, a number of small power plants with some specific purpose in view have also been constructed. To give a few examples, these small power plants are running submarines and an ice-breaker, providing electrical power to mid-ocean unmanned weather stations and to colonies of scientists stationed near the North Pole. Such power generating units are compact and can run over long periods of time without refuelling. In order to be able to understand this new source of energy and also as to why it was discovered only in this century, one must understand the structure of matter in some detail.

STRUCTURE OF MATTER

All matter consists of very tiny particles called atoms. An atom itself consists of a central, positively charged core—called the *nucleus*, with negatively charged *electrons* revolving round it. The mass of the atom is almost entirely concentrated in the nucleus. The nucleus, in its turn, is composed of two types of particles, *protons* and *neutrons*. The protons carry a positive charge (equal in magnitude to that of an electron) but the neutrons are uncharged particles. Since an atom as a whole is electrically neutral, the number of electrons in the outer orbits is equal to the number of protons in the nucleus and this number is called the *atomic number*. The total number of particles, both protons and neutrons, in the nucleus is called the *mass number*. For a given atomic number one can have nuclei with different mass numbers and these are referred to as *isotopes*. Since the chemical properties of an atom depend on its atomic number the various isotopes of an element are chemically indistinguishable.

Any particular isotope of an element is indicated by attaching the total number of particles in the nucleus (i.e. the mass number) as a superscript to the chemical symbol. Often the atomic number, i.e. the number of protons inside the nucleus is also indicated as a subscript either to the left or to the right of the chemical symbol. For example, consider the two important isotopes of hydrogen, which are ${}_1\text{H}^1$ and ${}_1\text{H}^2 \equiv {}_1\text{D}^2$. These differ in the fact that the heavier isotope, ${}_1\text{D}^2$, usually called deuterium, contains one proton and one neutron inside the nucleus, whereas in the lighter isotope ${}_1\text{H}^1$, there is no neutron in the nucleus. Water, in which ordinary hydrogen (${}_1\text{H}^1$) has been replaced by its heavier isotope ${}_1\text{D}^2$, is called heavy water. Another important example is that of the two isotopes of uranium, ${}_{92}\text{U}^{235}$ * and ${}_{92}\text{U}^{238}$. Both have the same number of protons (92) but the number of neutrons is $(235-92=)$ 143 and $(238-92=)$ 146 respectively. Natural uranium is a mixture of nearly 99.3 per cent of ${}_{92}\text{U}^{238}$ and 0.7 per cent of ${}_{92}\text{U}^{235}$. The technological difficulty in separating ${}_{92}\text{U}^{235}$ from natural uranium (the separation requires physical processes) can be gauged from the fact that whereas the price of natural uranium is about Rs. 200 per lb., that of pure ${}_{92}\text{U}^{235}$ goes up to about Rs. 50,000 per lb.

A nucleus may be stable or radioactive, i.e. it may spontaneously give off an α -particle† (Helium nucleus) or a β -particle† (electron) and transform into a nucleus of some other element. Radioactive nuclei also emit γ -rays†, which are

*Pronounced 'Uranium 235'.

† α , β , γ , are the first three letters of the Greek and are pronounced alpha, beta and gamma respectively.

similar to very high energy X-rays. In a large dose all these radiations are harmful to life and may even prove fatal.

NUCLEAR ENERGY

Apart from a few radioactive nuclei like those of radium and uranium, most nuclei occurring in nature are stable. However, it was found that if these stable nuclei are bombarded by high energy α -particles or protons or neutrons, they become radioactive. While studying the different nuclear reactions it was discovered that when uranium is bombarded by high energy neutrons something unusual happens. *A uranium nucleus breaks up into two nearly equal fragments releasing a lot of energy and two to three high energy neutrons. This process of splitting up of a nucleus into two or more nearly equal fragments is called fission.* The fission fragments are highly radioactive. The energy released is really stupendous. A cubic inch of uranium metal when completely fissioned can release energy equal to that contained in almost a train-load of coal holding a total of 1600 tons.

Soon after the discovery of fission, it was found that when very high energy neutrons (e.g. those produced in fission itself) interacted with U^{235} nuclei, in the majority of cases this led to fission. On the other hand their interaction with the U^{238} isotope resulted in fission only in rare cases (in the majority of cases the neutrons are just scattered with a much reduced energy or absorbed to produce the isotope U^{239}). For slow neutrons the situation is very different. Though U^{238} absorbs these neutrons just as it does the fast ones, the fission of this isotope by slow neutrons is not at all possible. However, the absorptive power of U^{235} for slow neutrons is a few hundred times larger than that for fast neutrons, implying that slow neutrons are very much more effective in causing the fission of this isotope. In other words, if one could sufficiently slow down the fast neutrons (produced in the fission process) the chance of these neutrons causing fission of U^{235} would increase a few hundred times. One consequence of this is that though in natural uranium the U^{238} isotope is about 140 times more abundant than the U^{235} isotope, it is the U^{235} isotope which absorbs slightly more slow neutrons than does U^{238} .

CHAIN REACTION

Since fission is caused by neutrons and in each fission process 2 to 3 neutrons are again liberated, the question arises if a mass of natural uranium can maintain a self-sustained chain reaction, i. e. if it can regenerate, in a given time, as many neutrons as are removed from the system by absorption or leakage.

The answer is—'No'. To maintain a chain reaction it is necessary that the number of neutrons causing fission should not diminish. Because of the presence of 99.3 p. c. of U^{238} isotope in natural uranium, which absorbs neutrons but rarely undergoes fission, too many neutrons are removed from the system without creating new ones. There are two ways of overcoming this difficulty. One is to take a mass of almost pure U^{235} . However, if this mass is too small, a large fraction of neutrons may escape out of the system and too few may be left for absorption in uranium. Since one expects the fraction of neutrons absorbed to be roughly proportional to the volume of the system (assumed spherical) and the fraction leaking out of the surface area, we can increase the relative absorption by increasing the mass of the material. (The volume of a sphere increases as the cube of the radius whereas the surface area increases only as the square of the radius). The volume that will just sustain a chain reaction is referred to as the critical size and the corresponding mass of U^{235} as the critical mass. Figure. 1.

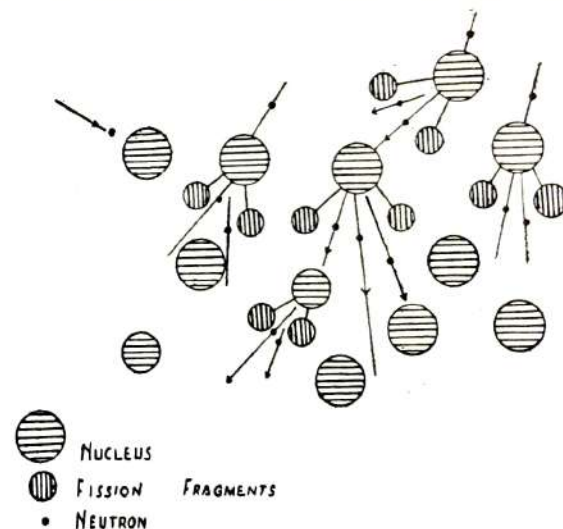


Fig. 1. Chain Reaction

As mentioned earlier, slow neutrons are highly effective in causing the fission of U^{235} . In case one wanted to establish a chain reaction using natural uranium, the only possibility is to increase the relative effectiveness of U^{235} by slowing down the fast neutrons emitted during fission. When a high energy neutron collides with any nucleus, it loses some energy and the fraction of energy lost is inversely proportional to the mass of the nucleus. A neutron will, therefore,

slow down rapidly by collisions with nuclei of low atomic weight, like those of H, D, Be or C. The medium which is used to slow down the neutrons is called a moderator. When neutrons have attained thermal equilibrium with the atoms of the moderator, they are referred to as thermal or slow neutrons.

Thus to get a self-sustained chain reaction with natural uranium one must have, in addition to the fissionable material, uranium (also called fuel), some other material for slowing down neutrons—i. e. a moderator. Any assembly of fuel and moderator (or for that matter an assembly of pure fissionable material) which is capable of maintaining a self-sustained chain reaction is called a reactor or pile. It turns out that a homogeneous mixture of natural uranium and graphite will not sustain a chain reaction, whereas a suitable heterogeneous assembly will. Such an assembly is realized, for example, by having uranium rods embedded in a graphite block.

The heat produced in the uranium rods due to fission is removed by sending water or air through tubes surrounding each uranium rod. The steam or hot gas then drives conventional turbines and electric generators. Figure. 2.

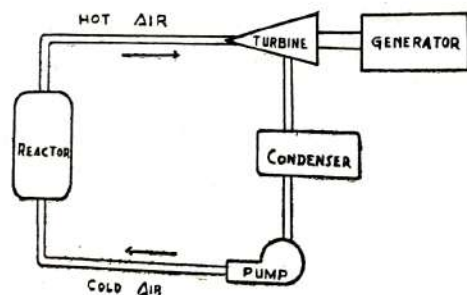


Fig. 2. Steam Cycle for a gas-cooled reactor

There are three basic advantages of using nuclear fuel; (i) reactors need refuelling only after long intervals of times, (ii) extremely high temperatures are produced, so that they are in principle capable of converting heat energy into electrical energy much more efficiently than is possible in conventional power stations and (iii) while they are burning fuel (U^{235}) they also produce other nuclei, e. g., plutonium (${}_{94}Pu^{239}$) which can be used as fuel. Already reactors are working, which in a given time, produce more fuel than they consume.

We have so far not talked about the problems associated with a fission reactor. The fission fragments produced during the working of a reactor are highly radio-

active. To stop these and the high energy neutrons from causing unseen injuries to persons working with the reactor, all reactors have to be enclosed in thick walls of concrete—about 8-10 ft. thick. Final disposal of the radioactive waste is another big problem. Some of these problems will be avoided when it becomes possible to use other nuclear reactions for energy generation.

So far we have talked of nuclei of atoms with large atomic number like radium ($Z=88$) and uranium ($Z=92$). These are unstable and in time decay into some other element. As a matter of fact, of the 103 elements known, the ones with their atomic number lying roughly between 8 (oxygen) and 75 (rhenium) are the most stable (leaving aside a few exceptions). Of the lighter elements, helium nucleus with atomic number 2 and mass number 4 (${}^4_2He$) is also very stable. Given a chance, the lighter nuclei like ${}^1_1H$, ${}^2_1H$, ${}^3_1H$ (three isotopes of hydrogen) have a tendency to 'fuse' and form ${}^4_2He$. When, say two nuclei of ${}^2_1H$ fuse to form ${}^4_2He$ a large amount of energy is released. The main problem is to get the two nuclei close enough so that they may interact and fuse. Under normal circumstances, because of their positive charge, they repel each other very strongly and stay out of each other's reach. To make them fuse, one has to provide them with enough energy so that in spite of the electrostatic repulsion, they can get within each other's range of nuclear interaction. There are two ways of providing this energy. One is the use of high energy accelerators where a beam of charged particles (say of ${}^2_1H$) is electrically accelerated to very high energies and then made to impinge on a stationary target, also of ${}^2_1H$. However, this is a very wasteful process since out of the total number of particles accelerated, only a small fraction is able to cause nuclear reactions, the majority just pass through the material. Thus compared to the energy we spend in accelerating the particles, the energy we obtain from fusion is very small. The other method, that of 'thermonuclear reactions'—used by the sun and the stars to generate their energy—is much harder to realise in the laboratory. These are the nuclear reactions that take place between light elements when they are heated to very high temperature—of the order of a few million degrees. Producing such temperatures and maintaining them for a reasonable length of time is a problem which has not yet been solved. The main difficulty is that of containment of such a hot gas. No solid container will serve, as everything will get vaporised long before such temperatures are reached. Even otherwise the contact of the hot gas with the walls of a cold solid container would at once cool it down and stop all nuclear reactions. Scientists have devised a most ingenious method of holding this electrically charged hot gas—technically called plasma, inside a "magnetic bottle" and away from all material boundaries. The present difficulty is that the plasma does not

stay inside the 'bottle' for long, it leaks out very fast. Efforts are being directed at making magnetic bottles that will hold the plasma for long enough time. Figure 3.

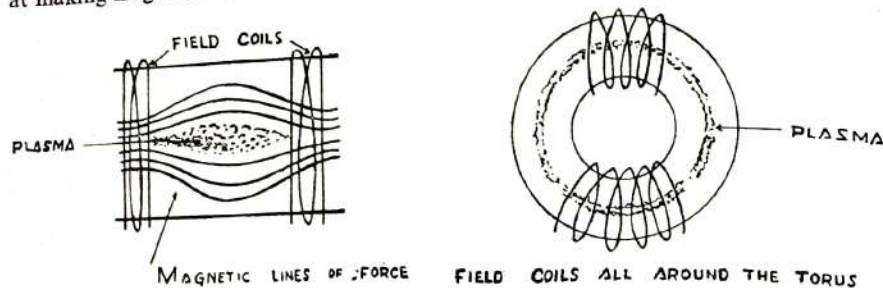


Fig. 3. Magnetic Bottles

In true Indian tradition of foretelling the future 'from the stars' the late Dr H. J. Bhabha, Chairman of the Indian Atomic Energy Commission, while presiding at the first International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1955, predicted that fusion energy would have been harnessed for peaceful purposes within the next 20 years. Western scientists working in this field are more pessimistic. Anyway, one looks forward to the time when fusion energy will have been harnessed. Deuterium is "plentiful" in sea water. The cost of extracting deuterium from a litre of sea-water is estimated at 10-15 paise—for which one would get energy equivalent roughly to that of 300 litres of petrol. The total energy content of deuterium in sea-water is estimated at 10^{20} kw-years, which is almost a limitless supply.

K. N. MEHRA

CONQUEST OF SPACE

HOPEFULLY man shoves his tiny ball of gadgets into space. Crudely it samples the criss-crossing energies some of which come to it from infinity. The data are sent down to earth where scientists begin sorting and interpreting the information. With this beginning from the microcosm set in the cosmic vastness a new theory of the Universe and creation may evolve leading us to the conquest of space.

Although a proper conception of the solar system was not finally established a couple of centuries ago, accounts of lunar visitations can be traced back to nearly 2000 years. The early devices ranged from teams of trained swans to suctorial proclivities of powerful whirlwinds. But the first person, full to appreciate the potentialities of rocket was, in all probability, the Russian-born son of a Polish father and a Russian mother, K. E. Ziolkovsky. He published a thesis on it in 1903.

The next step was to devise a rocket suited to the new propellants and such a rocket was fired at Auburn on 16th March, 1926 and rose modestly to the occasion. After many experiments on the fuel used in the rocket, the first Vanguard V-2 was fired for upper air research in June, 1946 and this rose 67 miles up into the sky.

Since World War II, the British and American rocket and inter-planetary societies have been joined by a host of others. A number of miniature stations have been launched into space as a step towards interplanetary travel.

Rocket and its working

In the present state of knowledge, the rocket motor is essential to the conquest of space as no other prime motor is able to operate in vacuum. The rocket is a jet engine, that is to say, it produces thrust by virtue of the reaction of a jet of exhaust gases.

Most other jet engines produce their exhaust gases by burning a fuel in a stream of air, but the rocket is unique in that it carries within itself not only the fuel but also the oxygen required. Its operation is thus independent both of altitude and forward speed. In the liquid, propellant rocket, both propellants are carried as liquids, and the combustion cycle is carried out at high pressure so that the engine bulk is kept to a minimum, that is, it is both light and small for a

given thrust. The greatest drawback of the rocket is its very high consumption; this stems from the fact that it carries its own oxygen.

We shall not enter into the details of the theory of rockets here. All self-propelled vehicles, within a fluid continuum are driven along on the basis of the momentum principle. This states that the reaction force produced by the mass of a fluid is equal to its rate of change of momentum. Rocket propulsion method differs from other propulsion methods only in the relative masses and velocities involved. In all other propulsion devices, the mass accelerated for a given thrust is large and the velocity to which it is accelerated is small. In the rocket, the velocity of the ejected mass is very high (up to 75000 ft. per sec. i. e. more than 5000 miles per hour.)

Launching of Artificial Earth Satellites

In August 1953, a conference was held at Oxford on Rocket Exploration of the Upper Atmosphere. Near the end of the discussion, a paper was presented by E. L. Singer on 'Astro-physical Measurements from an Artificial Earth Satellite.' Few of those present imagined that within two years plans would already have been made for a practical realization of the possibilities outlined by Singer.

The proposal was to launch small bodies into elliptical orbits, in which they will travel round the earth at a height of about 300 miles above its surface. One of the major advantages afforded by the opportunity of including observing instruments in a satellite of this kind, is that measurements may be made continuously at points very approximately at the same height above the surface, which is impossible by means of rockets. Secondly it shows the earth as it was never seen before.

The first satellite was launched in space by a three stage rocket on Oct. 4, 1947 by Russian Scientists. In the first stage it employed a rocket motor with a sea-level thrust of 27000 pounds. This accelerated the system to between 3000 and 4000 miles per hour in about two minutes. After travelling about 40 miles the second stage motor took over and accelerated the system to about 11000 miles per hour at an altitude of 130 miles. Finally when a height of 300 miles had been attained, the third-stage motor fired and accelerated the satellite into the orbital speed. The satellite itself was a sphere about 2 feet across carrying instruments and radio transmitter. It began to orbit the earth in a period of just over $1\frac{1}{2}$ hours.

The second Soviet satellite, sent up in Nov. 1957 was larger and more massive so that it could carry more complex equipment.

After this, many satellites have been fired with different instruments. Some have carried animals like dogs, monkeys, mice etc. and the effect of altitude has been observed on them. Lyka was the first of these.

Artificial satellites of this kind are of great value to the astronomers. Not only do they tell us more about the upper regions of the earth's atmosphere, but they allow us to study certain phenomena which cannot be investigated from ground level because of the shielding effect of the air mantle. Sputniks and cosmic rockets are now launched by means of multistaged rockets as in the case of Lunik II, a method first proposed by K. E. Tsiolkovsky.

Difficulties of Space Navigation

The difficulties of space journeys were mainly due to two factors. The first of these was our lack of knowledge of the human element. We did not know how man will behave under the strain of the utter isolation of space.

The second factor was the insistent need for the utmost economy of fuel.

Problem of Fuel

The second difficulty was solved to some extent in the Russian multistage-rocket Lunik II which struck the surface of the moon on 14th Sept., 1959. So only the medical and biological problems remained to be considered.

Physiological Problems

The physiological problems of flight into space are of two sharply contrasted kinds—those which can be solved on earth before such flight begins, and those to which answers are to be found only in space itself.

Excessive Acceleration

Before embarking in the space vessel, when we stand on earth we feel our normal weight. If the ground were not there to support us, we should fall towards the centre of the earth with an acceleration of 32 feet per second known as g , the acceleration due to gravity, and in this case we feel no weight in spite of the gravitational field.

Let us now step into a rocket space vehicle. Suppose that power is increased so that the ship accelerates upwards at 32 feet per second. This is equal to one g and we shall in consequence feel twice as heavy as before.

In order to get away from the earth, a space traveller must submit to an acceleration which will increase its apparent weight. What effect it would have in

space-travelling ? Fortunately this can be answered without having to take off on a space-voyage. The harmful effects of too much centrifugal force have been known for years. The same type of difficulty will arise in space-travel.

Pilots making sharp turns in the aircrafts, find themselves liable to a temporary black-out of vision. At a revolution fast enough to produce 3 g, the subject of the experiment finds it difficult to raise his arms, legs or head because they are all in effect three times their normal weight. At about 5 g all vision of outside objects disappears after some 3 seconds, and they are replaced by a grey field, which soon becomes black. If another $\frac{1}{2}$ g is added beyond this black-out stage, unconsciousness will probably supervene in 5 or 6 seconds.

The explanation is simply that at these accelerations the blood becomes so heavy, that the heart cannot pump it up to the level of the eyes or brain.

Blood pressure can be increased somewhat by shouting or holding the breath, and by this means unconsciousness may be delayed for 15 seconds or more or a further 2 g even be tolerated.

Since the trouble is due to a difference of level between the heart and the brain and eyes, the obvious remedy is to bring them to the same level by lying down. The monkey and mice, which went up to 36 miles in a rocket from New Mexico in 1953 were subjected to 14 g for $2\frac{1}{2}$ seconds and $2\frac{1}{2}$ to 6 g for 5 seconds without any apparent harm.

Weightless

An object becomes weightless when it is free to move through space, without encountering resistance. In this situation, the sensations of a living body would be same i.e. they would give the impression of falling—the only time when living beings normally experience weightlessness is when they are falling towards the earth.

During a space-voyage the passengers will become weightless as soon as the motor power is cut off, as already explained, and will remain so until the motor is switched on again either when approaching the destination or for short periods during the navigational adjustments. Will the human body tolerate such prolonged periods of weightlessness, which the senses will interpret as a perpetual fall, if they are to last for days on a voyage to the moon or for months on the way to Venus or Mars ?

Some people can endure weightlessness for half a minute while to others it becomes intolerable after only a quarter of a minute. But what will happen on a long space journey ? The only solution to the problem, if prolonged weightlessness should

prove intolerable to normal beings, is to make use of people whose balancing organs have been put out of action, either by disease or by surgical operations.

Respiration and food

Dr H. E. Ross gives 6.3 lbs per man per day as the total food, oxygen and water to be carried. On these assumptions, Ross calculated that about 200 lbs of these stores would be needed per man for going to the moon and back with two days there and 8 tons per man for a voyage to Mars and back.

Many writers have suggested that space-ships should incorporate some features to save the greater part of the weight of stores, which they would have otherwise to carry.

A proposal, to save some of the weight of stored oxygen, by starting the voyage with a cabin, full of pure oxygen, has been criticized by Haldane as producing too great a risk of fire.

However, an atmosphere of oxygen at low pressure may be used; but the question now arises what would happen, if the cabin wall were holed by a meteorite, or damaged so as to spring a leak, to let all the air escape ?

A final point about the cabin air is that it could become extremely hot while the ship is travelling at high speed through the earth's atmosphere during take-off or landing.

Harmful Radiations

The space-traveller is exposed to many harmful radiations like the ultra violet light from the sun, the X-Rays and other cosmic radiation. But man has, to a very great extent, got over these difficulties and one after another successful manned spaceflights are being undertaken both by the U. S. A. and the U.S.S.R.

Possibilities of conquest of space

Of the nine major planets and 31 satellites in the solar system, most are clearly unsuitable for direct exploration, each planet presents its own problems, and at the moment it is not worth discussing landing upon any, but the three nearest ones, the moon, Mars and Venus. The moon comes first because of its relative closeness (238,840 miles), but of the three worlds the Mars is by far the least hostile.

The Russians expected to land on and explore the moon by the end of 1965. Already they have done much in that direction. It was a Russian—Yuri Gagarin—

who was the first man in the world to go into orbit round the earth on board the satellite space-ship VOSTOK on April 12, 1961. After carrying out the planned investigations and the assigned flight programme, the space-ship VOSTOK made a safe landing in a predetermined area of the Soviet Union. The space pilot, Major Gagarin felt quite normal on landing and had no injuries or bruises. The first manned space-flight was thus accomplished very successfully by Russia. This was followed by a number of other manned space-flights by the U. S. A. and the U.S.S.R till finally the world witnessed *the six months space success of* the U.S. scientists. Beginning with a close look at the moon in March, 1965 with U. S. Ranger 9, which crashed in one of the moon's craters after transmitting the first live close-up photographs of the lunar surface, the United States of America shattered eight earlier space-flight records with the *Eight days in space by Gemini—5*, between 21 and 29 of August, 1965 carrying astronauts Conrad and Cooper, which demonstrated conclusively that man can endure an eight-day flight to the moon and back. The latest flight took the world closer to a manned voyage to the moon within this decade.

The United States has by now successfully accomplished nine manned flights and the Soviet Union eight. A journey to the moon is within man's reach. Flight to the other stars, till recently, was spoken of as something fantastic. But science today holds out the prospects of realizing this bold dream.

New Concepts In Mathematics

THE TOPIC OF SETS

J. D. VAISH

THE SCHOOL MATHEMATICS STUDY GROUP of U.S.A. and the School Mathematics Project of U.K. have given a re-orientation to the Mathematical concepts. The basis of these concepts for the students of elementary schools centres round the topic of sets. These new concepts are becoming very popular in every country. We too may adopt them in Rajasthan. The sooner it is done the better.

The concept of SET is fundamental in everyday life. The idea is a very simple one.

The idea of set is merely that of a collection of a bunch of things etc., e.g. a collection of pencils, a set of plates, a bunch of flowers.

As soon as prehistoric man grasped the idea of a group of animals grazing together on the range he formed the idea of SET. Despite the age of the idea of set, it is still the starting place for many of the most modern mathematical ideas.

Membership in a Set

You are accustomed to speaking of sets. Sometimes you give them other names. For example you say your school's basketball team. This team is made up of a certain number of players, regulars and substitutes. When the teacher

speaks of the basketball team, he means the set of 10 or 12 boys (whatever their number may be) who are on the team. Another example : you may speak of the Presidents of the All India National Congress, past and present. You know what this set is because you have a complete description of the set. However, if you say 'set of good football players' in your school, you have not a good or sufficient description for defining a set and thereby you cannot be sure of the members.

REMEMBER—If you have a description of a set, you can tell whether something is a member of the set.

The objects that make up the set are called the **ELEMENTS OR MEMBERS OF THE SET**.

The English alphabet has 26 elements. Each element is said to *belong to the set*. Sometimes we say that each element *is a member of* or *is contained in* the set.

The symbol $\in$ is used to say 'is a member of'.

The symbol $\notin$ means 'is not a member of'.

We can say " $b \in$ the set of English alphabet."

"2 $\notin$ the set of English alphabet."

Identifying sets

Sets can be put down as 'set of proper fractions', 'set of 6 even numbers', 'set of titles of Indian Army Officers', and so on.

There is a simpler way of expressing it by listing the elements within brackets, e.g. $\{1, 2, 3\}$, $\{1, 3, 5, 7, 9\}$, $\{2, 4, 6, 8, 10, 12, 14, 16\}$, $\{\text{Vowels of the English Alphabet}\}$, $\{\text{States which formed Rajasthan}\}$.

At times A, B, C, D are also used to denote a complete set, then we can say $2 \in A$, $14 \in C$, $3 \notin D$ and so on.

The Empty Set

A set with no members is called the **EMPTY OR NULL set**. Symbolically it is put down as $\varnothing$.

Frequently it is necessary in mathematics to refer to Empty set also; hence a special name with a particular symbol has been assigned to it.

Finite Set

A set in which you can count the elements, a set in which you can find its last element, is called a **FINITE SET**, e.g. $\{1, 2, 3, 4, 5\}$.

Infinite Set

A set in which you cannot count the elements, a set in which you cannot find its last element, is called an **INFINITE SET** e.g. $\{2, 4, 6, 8, 10, 12, 14, 16, \dots\}$

Another Method of Identifying a Set

$K = \{a; a \in P, a \text{ divisible by } 2\}$.

It means a set of P (positive integers) divisible by 2; so it is another way of writing $K = \{2, 4, 6, 8, \dots\}$.

$D = \{a; a \in P, a \leq 6\}$.

It means that the elements are less than 6 and are positive integers; so, $D = \{1, 2, 3, 4, 5\}$.

Now, $A = \{a; a + 0 = a\}$.

It means the elements are ordinary arithmetical numbers, so $A = \{1, 2, 3, 4, 5, 6, \dots\}$

Sometimes * is written in place of a and / in place of $(:)$.

$K = * / *$ is a positive integer divisible by two;

$D = * / *$ is a positive integer less than 6;

$A = * / *$ is a positive integer $* + 0 = *$.

Sub Sets

The two sets $A = \{0, 1, 2, 3, 4, 5\}$ and $B = \{2, 3, 4\}$ are such that every element of B is subset of A. So in such a case we say that B IS A SUBSET OF A. The symbol $\subset$ indicates that one set is a subset of another. $B \subset A$ is read as "B is a subset of A".

Union of Sets

Consider $A = \{1, 2, 3, 4\}$ and $B = \{2, 3, 4, 5, 6, 7\}$.

They are two separate sets. There can be a set $C = \{1, 2, 3, 4, 5, 6, 7\}$ —in this set C we find that every element of A is an element of C, every element of B is an element of C. So we say that set C is union of set A and set B.

The symbol for union is U.

$A \cup B$ will be read as A union B.

$A \cup B = C$ will be read as "A union B is equal to C."

Note :—Union of two sets will also be a set.

Intersection of Sets

Set $A = \{1, 2, 3, 4\}$ and $B = \{3, 4, 5, 6, 7\}$.

Now consider another set $D = \{3, 4\}$.

The elements of set D are in both set A and set B. Set D is said to be the intersection of set A and set B. The intersection is thus the set of elements in common to the other two sets. Thus $A \cap B = D$, which is read as "A intersection B is equal to D".

Disjoint Sets

Sets which have no elements in common are called Disjoint Sets e.g. $A = \{2, 3, 4, 5\}$; $B = \{20, 25, 30, 35\}$.

Complement of Sets

Consider $A = \{3, 4, 5\}$; $B = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$. Now $A \subset B$.

Take a set $A' = \{1, 2, 6, 7, 8, 9, 10\}$. This set has all the elements of B which are not in A.

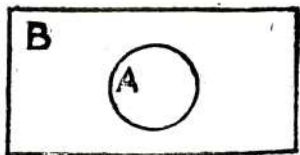
A' is called the complement of A with respect to B.

In this case $A \cup A' = B$.

Venn-Diagrams

In the study of sets, at times, we use a diagram known as Venn Diagram.

Consider a diagram as shown on the right: B is a rectangle which has a circle A in it.



Say all the elements of the circle are styled as set A, and all the elements of the rectangle are styled as set B.

So all the elements of A are also elements of set B.
 $\therefore A \subset B$

Consider another diagram:

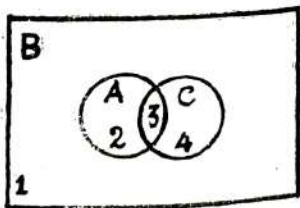
B is a rectangle with two circles A & C in it which intersect each other.

Now $A \subset B$

$C \subset B$

A and C are subsets of B

Also $A \cap C = 3$.



Variable

The expression $x + 3$ has the letter x in it. We do not know the numerical value of $x + 3$ because x is not a number. However, if we replace x by 7, $x + 3$

becomes $7 + 3$ or 10. If we replace x by 13, $x + 3$ becomes $13 + 3$ or 16. If we replace x by $11\frac{1}{2}$, $x + 3$ becomes $11\frac{1}{2} + 3$ or $14\frac{1}{2}$.

A symbol such as x in the expression $x + 3$, that can be replaced by any number from a set of numbers, is called a *Variable*. A variable is thus usually a letter.

Domain of a Variable

The set of numbers which can be used to replace a variable in an expression is called the *domain* of the variable.

THINGS WORTH REMEMBERING

Properties

1. If you have a description of a set, you can tell whether something is a member of the set.
2. Every set is a sub-set of itself.
3. For any two sets R and S, it is true that $R \cup S$ is the same set as $S \cup R$. This is the commutative property for union of sets.
4. For three sets A, B, C, it is true that $(A \cup B) \cup C = A \cup (B \cup C)$. This is the associative property for union of sets.
5. For any sets A and B, it is true that $A \cap B$ is the same set as $B \cap A$. This is the commutative property for intersection of sets.
6. For any three sets A, B, C, it is true that $(A \cap B) \cap C = A \cap (B \cap C)$. This is called the associative property for intersection.
7. If $A \subset B$ and $B \subset A$, set A is the same set as set B. We say that sets are equal i.e. $A = B$.

Words and Expressions

(a) Finite sets; (b) Infinite sets; (c) Intersection of sets; (d) Is contained in; (e) Member of a set; (f) Subset; (g) Union of sets; (h) Venn diagrams; (i) Empty or Null sets; (j) Domain; (k) Disjoint sets; (l) Complements of sets; (m) Commutative property for union; (n) Commutative property for intersection; (o) Associative Property for union; (p) Associative property for intersection; (q) Variable; (r) Domain of a variable.

Understandings

1. A set may be identified by listing its member in braces.
2. A set may be finite or infinite or it may be empty.

3. Sets may be combined by union and by intersection.
4. A variable is a symbol, usually a letter, which can be replaced by any number from a set of numbers.
5. The set of possible numbers for a variable is its domain.
6. Every set is a subset of itself.
7. Sets have the associative and commutative property for both union and intersection.
8. Venn diagrams help to illustrate properties of sets.

Skills

You should be able to

- (i) Tell when a set is finite or infinite.
- (ii) Find solution sets for some equations.
- (iii) Find values of expressions after numbers have been substituted for the variables.
- (iv) Form unions and intersections of sets.
- (v) Find complements of sets.
- (vi) Use venn diagrams to illustrate subsets, complements, intersection and unions.

THE TALENTED PUPIL

As the future Scientist

K. N. SAXENA

WITH THE PROGRESSIVE DEMOCRATISATION of educational opportunities, it has become imperative that the talented pupil should not be allowed to suffer at the altar of the mediocre and the slow learner. According to the psychology of individual differences and the distribution of intellectual abilities in the population, one can easily spot a 2% extreme in such a distribution curve towards the right side. Children of this group seem to be endowed not only with superior mental abilities but also possess marked interests and specific aptitudes. Although in flesh and blood they appear to belong to the same stock but so far as intellectual sagacity and its application is concerned they seem to mark out an individual contribution of their own, which can ordinarily be characterised as superior ingenuity.

According to the age-old theory of 'classification of pupils', these very facts are taken into account while classifying the pupils into academic categories. It has been experimentally proved that this classification is not a very healthy tendency so far as psychological principles are concerned, nevertheless it has also been empirically established that it is not proper to subdue the superior intellect of a few to the rigours of mediocres and the slow learners. The two ends of a curve, if

allowed to overlap, will produce a confusion which will bring about stagnation, chaos and indiscipline.

The talented child is a product of heredity and environment. Even in Socialistic countries, they are inclined to believe it, of course, in their own guarded way. One cannot ignore a fact that a gifted child, even if brought up in a gently, medium academic environment, will blossom up in the near future while a backward child, even if brought up in an accelerated, rich academic environment cannot do so with rapidity, economy and ease. The case of Ramanujam is too obvious. Such gifted children are present in rural, semi-urban and urban areas. The only job that an educationist or a teacher has to do is to spot such genius and foster their talents in the best possible way.

With the modern age of science and technology, it is very challenging for the educationists and teachers today to spot talented pupils in science and to foster their talents so that they can grow into future scientists of the country. Experiments have shown that out of the multitudes of interests, the specific aptitude begins to develop at an early age of 12+ to 14+, meaning thereby that if children at this cross-road of age are examined for the possession of a specific aptitude in science, it should be possible for the teachers to nurture the identified talent or, more specifically speaking; special aptitude.

THE EXPERIMENTS conducted under the Westing House Science Talent Search Scheme in U. S. A. the 'olympiads' in Hungary, Poland and the Soviet Union, the public Citizen Halls of Japan etc. are noteworthy contributions in this direction. This scheme in U. S. A. and Soviet Union has produced a long band of future scientists and technologists. In the Soviet Union, Scientific Olympiads start at an early stage of school education viz., Class Five. These types of competitions to identify the gifted have been accepted as a national scheme and are vitally nurtured by the intelligentsia of the Soviet Union. The competitions are conducted by eminent scientists and Academicians. This is because of the fact that the Soviet people believe that the future scientists can only grow from the tiny cerebrums in schools. Similar is the conviction of the people in United States. The science clubs, the science fairs and the Science Talent Search Scheme are amalgamated together to form one compact whole programme for identifying and nurturing scientific talents.

The Soviet people, in spite of their absolute socialistic philosophy of life, could not ignore the claims of tiny-tots, heading towards big achievements. They had to open four separate schools for talented school children where these children

are brought up under the special care of University teachers. In addition to this, they follow accelerated programmes of education, specially science.

THE NATIONAL COUNCIL of Educational Research and training started a Science Talent Search Scheme as a pilot project in Delhi in 1963. The main objectives were to identify scientific talents at the close of the secondary stage and to foster such talents in the best possible way. This pilot project was a big success and it was really possible to locate some bright students in science who possessed a real aptitude for scientific work.

In 1964, this scheme was extended all over India and an all India test was administered all over the country at all the district headquarters. The selection procedure consisted of the use of a Science Aptitude Test, an essay paper, a project report of a scientific topic and an interview. On the basis of these tests, 354 students were selected from all over the country for the awards of scholarships, provided they joined courses in basic sciences. In 1965, 325 students were selected for a similar award.

The follow-up programme for these talented scholars consists of the maintenance of a cumulative record card, interpersonal contact with the awardees and their teachers, organisation of summer schools and regular correspondence with scholars on academic matters.

Books on most recent scientific themes are awarded each year to the scholars to keep them in touch with the current scientific developments.

It is also being considered that this Science Talent Search Scheme should be so planned as to cover up the entire period of education of the scholars e. g. from B. Sc. 1st year to the Doctorate level. Those students who possess aptitude can definitely choose to be on the side of this scheme and thereby fulfil their ambitions of scientific research. An effort will also be made to keep contact with national laboratories and big industries so that these future scientists can get professional adjustment without any loss of energy and time.

It is hoped that with this National Scheme of Science Talent Search, it will be possible to produce a band of future scientists in the country, who will be able to man the national and the defence laboratories. In addition to this, these talented scientists will also be able to enrich the staff of the Universities and the colleges all over the country.

Here it will be necessary to exercise a word of caution against the whole scheme. Firstly, the selection procedure cannot be regarded as absolutely fool-proof

K. N. Saxena : *The Talented Pupil*

because of very obvious reasons and secondly, our methods of teaching and evaluation at the University are still quite traditional. Thirdly, to spot a talent is easy but to keep up the internal enthusiasm of a searched talent is an uphill task. In the background of all three factors, it is still hoped that it will be possible to see a day when an appreciable percentage of the awardees will flourish as our future scientists. This day is not very far and then the national reconstruction can easily be speeded up with added prestige.

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हिन्दी सूची

शिक्षण

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"Naya Shikshak" Jan., 1966

संदर्भ

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१. लोक विज्ञान : उदयपुर।
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Appendix to "Chemistry in Schools"

Chemistry Syllabi for classes IX to XII in Punjab

Classes IX, X (High Classes) :

1. Physical and Chemical changes. Elements, compounds and mixtures. Metals and non-metals. Chemical affinity, chemical combination and decomposition.
2. Solution, decantation, filtration, evaporation and distillation. Saturated solution, crystal, crystallization, sublimation. Deliquescent bodies.
3. Composition of air, Oxygen, nitrogen. Impurities of air. Air mixture. Breathing. Action of plants on carbondioxide.
4. Properties of water and its composition by electrolysis. Rain, spring, mineral and sea-waters. Hard & soft waters, softening of hard waters.
5. Burning of a candle, parts of a candle flame. Oxidation and reduction, organic and inorganic compounds.
6. Preparation, properties and uses of (a) Oxygen, hydrogen carbondioxide, sulphurdioxide and ammonia (b) hydrochloric sulphuric and nitric acids; action of metals on these acids. Tests for chlorides, sulphates and nitrates.
7. Allotropy of carbon; sulphur and phosphorus (red and yellow). Effect of heat on sulphur in a closed vessel or in air. Matches.
8. Ores, alloys and properties of copper, mercury, silver, zinc, lead, tin, iron and aluminium. Important salts of sodium and potassium. Lime, slaked lime, calcium carbonate and calcium sulphate and their different forms.

Class XI : (Hr. Sec. Pre-University Class)

General and Physical Chemistry :

1. Nature of matter. Molecules and atoms. Symbols and formulae. Chemical equations. Calculations of percentage composition

from the formula of a substance and vice-versa. Simple problems based on chemical equations.

2. Dalton's atomic theory and its modern concept. Law of chemical combination with examples, their deductions from Dalton's atomic theory.
3. Boyles' law, Charles' law of partial pressures, Grahms' law of gaseous diffusion. Calculations using gas equation and Grahms' law.
4. Avogadro's law and its applications.
5. Molecular weight, determination by Victor Meyer's method; equivalent weight, determination of metals only; atomic weight, determination by Dulong and Petit's law only. Relationship between equivalent weight, atomic weight and valency.
6. Elementary study of the structure of the atom as exemplified by the elements of the first two periods of the periodic table. General idea of electrovalency, covalency with simple examples.
7. Electrolysis and their applications. Elementary idea of the Arrhenius theory of ionisation and its important applications. Differences between ionic and molecular reactions.
8. Definitions, methods of preparation and characteristics of acids, bases and salts. Classification of salts with examples.

Inorganic Chemistry :

1. Oxides and their classification. Oxidation and reduction with common examples.
2. Nitrogen and carbon dioxide cycles. Combustion and flame. Reciprocal combustion. Structure of the flames. Mention of ignition temperature. Fire extinguishers.

Water. Purification of mineral water for drinking purposes. Hard and soft water. kinds and disadvantages of hardness of water. Softening of hard water by the use of lime, soda and permutit. Composition of water by electrolysis.

4. Occurrence, laboratory preparation, properties and uses of hydrogen, oxygen, ozone, hydrogen peroxide, chlorine, hydrogen chloride, bromine, iodine, hydrogen sulphide, sulphur dioxide, sulphur trioxide, nitrogen, ammonia, nitric acid, carbon monoxide and carbon dioxide.
5. Manufacture of hydrogen, chlorine (from brine), hydrochloric acid (from common salt), bromine, iodine (from sea weeds), bleaching powder, sulphur mining), sulphuric acid (chamber and contact processes), ammonia (Haber process), nitric acid (from nitro ammonia and air), phosphorus (electrothermal process), red phosphorus. Safety matches, Mention of producer gas and water gas.
6. Allotropic forms of sulphur, phosphorus and carbon.
7. General characteristics of metals and non-metals. Occurrence, metallurgy and important alloys of : Sodium (from caustic soda), copper (from pyrites), silver (by cyanide process), aluminium (from bauxite) lead (from galena) and cast iron (from oxide ores, wrought iron).
8. Preparation and properties of caustic soda, (Nelson and Castner-Kellner cell), washing soda (Solvay's process), common salt (from sea water), copper chloride, copper nitrate, copper sulphate, silver nitrate, mercurous and mercuric chlorides, alum, potash alum, lead nitrate, red lead, mention of white lead, ferrous sulphate, Mohr's salt and ferric chloride.
9. Tests of sodium, potassium, ammonium, copper, silver, mercury, aluminium, lead, iron, chlorides, bromides, iodides, sulphides, sulphites, sulphates, nitrates, carbonates and bicarbonates.

Class XII : (Pre-Engineering/Pre-Medical/ 1st Year T. D. C.)

General and Physical Chemistry

1. Atomic structure, periodic classification of elements. Meaning of periods and groups (brief discussion). Electronic concept of

valency, Electrovalency, covalency and coordinate valency with simple examples. Cations and anions.

2. Elementary concept of kinetic theory of gases (postulates and applications to Boyles' law and Charles' law).
3. Catalysis (excluding theories) and its applications.
4. Colloidal solutions, definition, common examples, their characteristics and applications.
5. Reversible reaction, Law of mass action (simple mathematical treatment). Exothermic and endothermic reactions (definition and examples). Le-Chatelier's principle and its applications.

Inorganic Chemistry

1. Comparison of phosphine with ammonia. Tri- and penta-oxide and chlorides of phosphorus. Phosphoric acids. Distinction between ortho-, meta- and para-phosphates.
2. Properties, detection, uses and metallurgies of zinc (from zinc blende), mercury (from cinnabar), tin (from tinstone) and iron (cast, wrought and steel).
3. Preparation, properties and uses, if any, of zinc oxide, zinc sulphate, mercuric iodide, Nessler's reagent, stannous and stannic oxides and chlorides.
4. Theory of tests of cations and anions including in the syllabus of practical chemistry.
5. Problems based on chemical equations including volumetric calculations.

Organic Chemistry

1. Definition, scope, sources and importance of organic chemistry. Purification of organic compounds (solids and liquids only) and testing of their purity by melting and boiling points. Detection and estimation of carbon, hydrogen, nitrogen (Dumas and Kjeldahl method), halogens and sulphur (Carius method). Determination of molecular weights of volatile compounds (Victor Meyer's method), acids (silver salt and volumetric method), bases (platini chloride method) and calculation of molecular formula therefrom. Determination of molecular formula of gaseous hydrocarbons by explosion method.

2. Tetrahedral disposition of carbon valencies. Significance of double and triple bonds. Isomerism and nomenclature of first five alkanes.
3. General methods of preparation, properties, other typical characteristics, tests and uses, if any, of the following classes of aliphatic compounds, taking the first member of every series as the specific example.
 - (a) Hydrocarbons (alkanes and alkenes). Manufacture and constitution of ethylene.
 - (b) Halogen derivatives (mon-, di-, tri- and tetra).
 - (c) Alcohols (monohydric). Mention of polyhydric alcohols. Manufacture of methyl alcohol from wood distillation and water gas and of ethyl alcohol from molasses and starch. Elementary idea of fermentation. Rectified spirit, methylated spirit and absolute alcohol. Mention of Power alcohol.
 - (d) Ethers.
 - (e) Aldehydes.
 - (f) Ketones (Mention of polymerization and condensation).
 - (g) Carboxylic acids (mono- and di-). Manufacture of acetic acid and vinegar. Formulae of butyric, palmitic, stearic and oleic acids. Properties and synthesis of succinic acid.
 - (h) Derivatives of acids. Acetyl chloride, acetamide, ethyl acetate, dimethyl sulphate and urea. Fats and oils. Their hydrogenation. Manufacture of soap.
 - (i) Substituted carboxylic acids. Monochloroacetic acid, glycollic acid, lactic acid and aminoacetic acid.
 - (j) Carbohydrates. Their chemical nature and classification Glucose and Fructose.
 - (k) Amines. Ethyl amine, Ascent and descent of homologous series. Mention of quaternary ammonium compounds.
4. Fractional distillation of coal tar. Asomerism of benzene derivatives (Korner's method).

5. General methods of preparation, properties, other typical characteristics, tests and uses, if any, of the following classes of aromatic compounds taking the first member of every series as the specific example.
 - (a) Benzene and Toluene. Simple treatment of kekule formula for benzene.
 - (b) Halogen derivatives. Chlorobenzene and benzyl chloride and their comparison.
 - (c) Nitro compounds. Reduction in acidic medium only. Mention of trinitro toluene.
 - (d) Amino compounds. Distinction between aniline and aliphatic amines. Diazonium salt formation and dye tests.
 - (e) Benzene sulphonic acid, phenol, benzyl alcohol, benzaldehyde and acetophenone, benzoic acid, benzoyl chloride, phthalic acid, salicylic acid and aspirin.

Practicals

Classes IX, X : Nil.

Class XI :

1. Study of the different parts and flames of Bunsen burner and Fish-tail burner.
2. Fitting up of Wash-bottle.
3. Preparation of Crystals of (i) potassium nitrate from an impure sample of nitre; (ii) copper sulphate from an impure commercial product; (iii) potash alum from commercial sample.
4. Qualitative Analysis: Identification of single salts soluble in water or dilute HCl.
Basic Radicals : Silver, lead, mercury, cadmium, copper, iron, aluminium, zinc, manganese, cobalt, nickel, calcium, strontium, barium, magnesium, sodium, potassium, ammonium.

Acid Radicals : Carbonate, bicarbonate, nitrite, nitrate, sulphide, sulphite, sulphate, chloride, bromide, iodide, phosphate, borate.
5. Volumetric Analysis : Acid-alkali single titrations, using phenolphthalein and methyl orange as indicators (No weighing).

Class XII :

1. Qualitative analysis of a mixture of two salts containing ions which do not interfere with each others' tests and also do not belong to the same group. Aqua regia should not be required for dissolving the mixture.
2. Simple volumetric analysis involving the following titrations dealing with the determination of equivalent weights, percentage purity of a substance, percentage composition.

tion of a mixture and number of molecules of water of crystallisation.

- (a) Acidimetry and alkalimetry : Standardisation of acids and alkalies. Strength of sodium carbonate, sodium hydroxide or potassium hydroxide solution. Solubility of oxalic acid in water at room temperature.
- (b) Oxidimetry involving potassium permanganate only. Estimation of ferrous and oxalates.
- (c) Argentimetry : Mohr's method only.

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